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A COAL CAR ABOUT TO RUN UPON THE TIPPING PLATFORM.

THE DEVICE IN OPERATION; THE TIPPING PLATFORM IS AT AN ANGLE OF 45 DEGREES.

A NOVEL GERMAN ELECTRIC COAL-TIPPING DEVICE.

A NOVEL GERMAN ELECTRIC COAL-TIPPING DEVICE.*

By Frank C. Perkins.

The accompanying illustrations and drawing show the details of construction and the method of operation of a new and interesting type of coal-tipping apparatus operated by electric power. It was constructed for use at the Hamburg harbor by the Vereinigte Maschinenfabrik Augsburg und Maschinenbaugesellschaft Nürnberg A.-G. As the water level of the Hamburg harbor varies from 6 feet to over 20 feet, special provision had to be made in this electric coal-tipping device for these differences of level in loading the coal barges.

An electric motor of 4.5 horse-power is utilized on one of the hoists mounted in the small building above, and another motor of 7 horse-power supplies the power for driving the drum and hauling in the ropes of this tipping apparatus. It has a capacity of from 10 to 20 tons, and takes cars having a wheel base from 8 feet 1½ inches to 13 feet. As noted in the illustrations, there are several of these electric coal-tipping machines in the Hamburg harbor, as well as a number of electrically-driven jib hoists and other labor-saving devices for unloading and loading coal and other material.

The capacity of these tippers is said to be from fifteen to twenty cars per hour, each holding from 10 to 20 tons. The electrical equipment, including the motors, controllers, and switchboard apparatus, was installed by the Siemens-Schuckert-Werke of Berlin.

The current for operating the motors of the coal tippers, the electric cranes, and hoists along the docks of the Hamburg harbor is supplied by underground cables at 440 volts, from the Kuhwärder power house of the Hamburg-American Line. The several electric coal tippers are located about 210 feet apart, with several tracks for handling the coal cars running along the wharves, as shown at the right in the illustrations.

In addition to the two small motors of 4.5 horse-power and 7 horse-power respectively, referred to above, a large direct-current motor is utilized, which supplies the main power for the tipper, having an output of 50 horse-power, and it is stated that in 30 seconds the car of coal can be tilted to 45 degrees and emptied into the coal barge. The installation is supplied with arc and incandescent lamps for illumination, so that these great labor-saving devices may be kept in operation day and night if it is found necessary.

NEW INCANDESCENT ELECTRIC LAMPS.—II.†

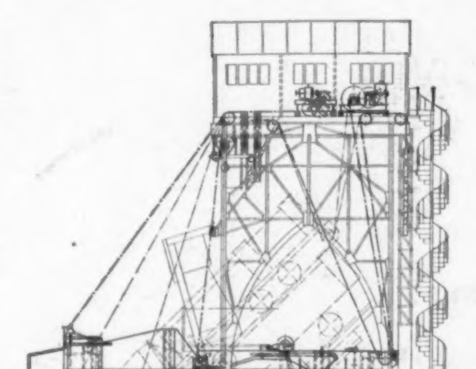
Zirconium Lamps.—The metallic carbides can be divided into two classes; those comprising the one class are decomposed by water, the others remain quite unchanged. Zirconium carbide belongs to the latter class, and has lately been used for the manufacture of incandescent filaments. According to the Sander patents—D.R.P. 133,701, 137,568, and 137,569—the technical exploitation of which in Germany after the dissolution of the Electrodon Gesellschaft was taken over by the Zircon-Glühlampenwerk of Dr. Hollefreund & Co., in Berlin, zirconium incandescent bodies are manufactured from the hydrogen or nitrogen compounds of the rare earths, especially of zirconium by the aid of some organic binding material. In the preparation of these compounds zirconium oxide, for example, is reduced by means of metallic magnesium, according to Winkler's process, in a current of hydrogen or nitrogen. For the sake of convenience hydrogen is used in practice for this purpose. Contrary to the analytical results of Winkler and Bayle, the pure hydrogen compounds should be obtained, if, according to the assertions of the patent, an excess of metallic magnesium is used, and heat is applied externally. Hollefreund has, so we understand, declared that the analytical results certify the formula to be ZrH_4. In order to remove the magnesia and the excess of magnesium, the product of the reaction is digested with dilute hydrochloric acid; it is then dried and made into a paste by the use of an organic binding material. The filaments produced by pressure are advantageously heated in an atmosphere of hydrogen to about 300 deg. C., in order to prevent oxidation. These filaments possess, however, an exceedingly low conductivity, so that they must either be started with a current of high voltage or be first heated up by means of some heating medium. If the latter process be used, a current of ordinary voltage is sufficient to keep the filament in a state of incandescence. When this has been done, the filament is continuously conductive, since the formation of carbide has been brought about. Hydrogen is then conducted into the receiver, and the current is allowed to increase gradually in order to make the filament coherent. As the current gets strong the filament alters its structure, becomes hard, shows a metallic appearance, and in its electrical properties resembles a metal. The incandescent lamps manufactured by this process, according to the assertion of Wedding, required 2 watts per candle, and were adapted for currents of low voltage.

The same company also put upon the market for a short time a so-called zirconium carbon lamp, which consisted of an ordinary carbon filament, having on its exterior surface, instead of as formerly, a graphite coating, a thin layer of zirconium metal. According to patents relating to this process—D.R.P. 140,323 and 141,353—the carbon filaments are heated electrically in a receiver in an atmosphere of gaseous zirconium compounds, whereby, for instance, 25-candle-power lamps may be converted into lamps of 30 to 32 candle-power burning at 220 volts with 2.5 watts, which show, therefore, the same economy as our present high-voltage incandescent carbon lamps.

The firm of Hollefreund & Co. have lately put on the market an improved zirconium lamp, which is supposed to burn with 1 watt per candle. As it is called a zirconium lamp, it might be imagined to be a metal lamp, analogous to the osmium and tantalum lamps. From the recent patents, however—D.R.P. 140,378, 146,555, 147,233, and 147,316—it appears that it is a carbide lamp, in which the proportion of carbon is reduced by suitable additions and treatment. To apply carbide for incandescent electric lamps is not new, since long before the publication of the Sander patents proposals were not lacking to apply carbides of the most diverse metals, including zirconium, for such purposes. Since, however, the results produced with carbides did not correspond with the expectations, this direction was overlooked.

It was by the addition of other suitable difficultly fusible metals, such as ruthenium or tungsten, for instance, that incandescent filaments were first obtained whose melting points lay very high, and which could be put to severe tests without prejudice to their durability. According to Boje, these lamps burned 60 hours at 0.3 watt per candle, for over 120 hours at 0.6 watt, and for over 1,000 hours at 1 watt. At this rate they show in the first 500 hours almost constant illuminating power. The length of the filament amounts to about 5 millimeters, with 0.6 millimeter thickness for one volt, so that it is necessary to have a number of filaments in series in order to produce incandescent lamps adapted to voltages of from 110 to 220 volts.

Iridium Lamps.—About the same time an iridium



A PLAN VIEW AND ELEVATION, SHOWING DIFFERENT POSITIONS OF THE TIPPING PLATFORM.

lamp made its appearance. Iridium, the application of which to electric lamps Edison had already proposed in 1878, is exceedingly hard and brittle, and cannot, therefore, be drawn into wire. But it can be rolled out into sheets about 0.8 millimeter in thickness. The use of iridium for incandescent lamps is now rendered possible by the Gülcher process—German patents 145,456 and 145,457. As hitherto nothing has been published on this subject, it may be of interest to quote here the patent claims: "Process for the manufacture of thin and uniform lamp filaments from pure iridium, in which the iridium in a finely-divided state is mixed with a binding material and dried in the air at a low temperature, and then strongly heated in the air, whereby the binding material is removed and the metallic iridium is left in a perfectly coherent form."

"Process for the manufacture of thin and uniform lamp filaments from pure iridium, according to patent No. 145,456, which sets out that the amorphous iridium is intimately ground with the binding material, whereby a somewhat stiff plastic mass is formed, from which the filament is produced. After drying, the filament is exposed to a current of hydrogen, whereby any oxide still remaining is converted into metallic iridium; then the filament, consisting only of metallic iridium and the binding material, is heated to a high white heat in contact with air."

The iridium lamp, like the osmium lamp, is only adapted for low voltages, and cannot by any means be considered as a real competitor of the carbon filament lamps, since the natural supply of iridium is, like that of osmium, very limited. The accumulator works of Gülcher in Berlin has probably only taken up this branch of manufacture because it has been shown that the osmium lamps are specially well adapted for low voltages and small light power. Lately they were almost exclusively used in conjunction with accumulators. Their relatively high price has in any case induced Gülcher to manufacture a similar but cheaper lamp.

Tungsten and Molybdenum Lamps.—To the metals which, on account of their high fusion point and non-volatile nature, are specially adapted to serve for glow lamps, belong tungsten and molybdenum. The idea of using tungsten and molybdenum for electric light purposes is by no means new, since several processes are known in which platinum or carbon filaments are coated over with a layer of these well-known metals. A process which was lately protected in the Austrian Patent Office by Dr. Alexander Just and Franz Hanaman—German patent 154,262, applied for April 15, 1903, accepted September 8, 1904—relates, however, to the manufacture of electric filaments from pure tungsten and molybdenum. It appears that the oxyhalogen compounds—for instance, the oxychlorides of these metals—are reduced by hydrogen at red heat with the formation of the metal, the halogen hydrogen compound, and water. An incandescent metallic or carbon filament was brought into an atmosphere of tungsten oxychloride vapor and excess of hydrogen, the reduced tungsten then deposited on the carbon or metallic filament, and so produced a body consisting of a core of carbon or metal and an envelope of tungsten. Researches have now shown that the reaction under known conditions runs in quite another manner. For instance, if a carbon filament is placed in an atmosphere of tungsten oxychloride in the presence of only a very little hydrogen, and heated to a high temperature by means of the electric current, it is thereby completely converted into a filament of pure tungsten. This process is exactly analogous to that one which has already been used for the manufacture of osmium filaments by the glowing of a carbon filament in an atmosphere of osmium tetroxide. In the case above mentioned the carbon combines with the oxygen of the oxychloride, forming carbon monoxide, the chlorine is reduced to hydrochloric acid, and the tungsten deposits in the place of the carbon according to the equation:

$$WO_2Cl_2 + C_2 + H_2 = 2HCl + 2CO + W,$$
$$\text{or, } WOCl_4 + C + 2H_2 = 4HCl + CO + W.$$

Once the carbon is completely replaced by tungsten, the current of hydrogen is purposely increased, and the tungsten deposits still more on the filament of tungsten already formed. It is, therefore, made stronger and more uniform, according to the following equation:

$$WO_2Cl_2 + 3H_2 = 2H_2O + 2HCl + W,$$
$$\text{or, } WOCl_4 + 3H_2 = 4HCl + H_2O + W.$$

The essential conditions which promote that reaction in which the carbon is replaced by tungsten are an excess of oxychloride, the presence of a very small quantity of hydrogen, and a high temperature of the filament. When there is an excess of hydrogen and a lower temperature of the filament the reaction proceeds quite differently, the oxychloride being reduced by the hydrogen alone, without the carbon entering into the reaction. In the case of molybdenum the reactions proceed in an analogous manner. The patent claim states as follows: "Process for the manufacture of incandescent filaments for electric light from tungsten or molybdenum, carried out by heating a carbon filament to a high temperature by means of an electric current in the vapor of oxyhalogen compounds of tungsten or molybdenum in the presence of a little free hydrogen, whereby the carbon is completely replaced by tungsten or molybdenum respectively."

In January, 1901, Dr. Fritz Blau and the Glühlampenfabrik Watt applied in Vienna for a patent for a process for the transformation of filaments of carbon into filaments of osmium and ruthenium. The claim runs as follows: "Process for the transformation of light-giving bodies of wire form of carbon into such of osmium or ruthenium, so arranged that thin carbon wire—incandescent lamp carbon—is burned in the absence of foreign reducing gases by the oxygen of the tetroxide of the platinum introduced in the form of gas, whereby the carbon wire is converted into metal wire."

Although the present manufacture of osmium lamps is not carried out in accordance with these processes, but exclusively by the paste method, nevertheless it may be of historic interest, and illustrate the connection of the Just patent with the Blau patent, if we give some account of them here.

According to a more recent patent application of Dr. Just, dated February 3, 1905, relating to supplementary processes to the substitution process, we find that the inventor has completely left the method set forth in his claim of April 14, 1903, and has gone over to the so-called paste process as it was brought out by Auer von Welsbach for the osmium lamps. This particular claim runs thus: "Process for the manufacture of lamp filaments from tungsten or molybdenum, or alloys of these metals, so carried out that the compounds of these metals, capable of being reduced to metal by means of hydrogen—such as oxide, sulphide, chloride, etc.—are worked up in powder form with a binding material free from carbon (such as water or any other fluid which leaves no residue on evaporating) into a plastic mass; the latter is then pressed into the form of a filament, and heated in an atmosphere of hydrogen until reduced, after which the product produced is either directly or after a drawing process used as a lamp filament."

It is well known, however, that the substitution process is now being used, since according to a com-

* Specially prepared for the Scientific American Supplement.

† Engineer.

munication of the incandescent lamp department of the Vereinigten Elektrizitäts Aktien Gesellschaft, of Ujpest, of April 29, this year, the first-named substitution process of Just and Hanaman is of especial value, since it permits of the production of exceedingly fine filaments of pure tungsten, whereby it is possible to produce lamps for 110 volts pressure, and relatively low candle-power, i.e., 32 candles. The firm lays particular emphasis upon the fact that filaments of so small a diameter cannot be produced by the paste method.

The exploitation of the tungsten lamp, after the process of Just and Hanaman, was executed by the incandescent lamp works of the Vereinigten Elektrizitäts Aktien Gesellschaft, of Ujpest, which possess the monopoly rights for Austria-Hungary, Russia, Belgium, Italy, Spain, and Portugal. The German patent is the property of the Wolfram Aktien Gesellschaft, of Augsburg, which has passed on the manufacturing rights to the firm of Georg Lüdecke & Co., of Lechhausen.

The process of Just and Hanaman is therefore connected with carbon. Since the present state of affairs never gives complete satisfaction, great efforts have been made to avoid the necessity of using carbon. Werner von Bolton has shown how to make wire from difficultly fusible metals, and lately, the chemist, H. Kuzel, of Vienna, has protected by patent a process which permits of the production of undrawn incandescent filaments from difficultly fusible metals in the form of amorphous powder without the aid of an organic binding material. As the working of the Kuzel patent for Germany has been taken over by the well-known Berlin firm, Gebrüder Pintsch, and in Austria lamps are already being manufactured in accordance with the Kuzel process by the firm of Kremenecky, in Vienna, an extract is given in the following lines from the only patent which has yet been granted, namely, the English one—No. 28,154, of 1904, filed December 22, 1904, accepted December 21, 1905. The new process makes use of the difficultly fusible metals—chromium, manganese, molybdenum, uranium, tungsten, vanadium, tantalum, niobium, titanium, thorium, zirconium, platinum, osmium, and iridium—in their colloidal state, namely, as "hydrosols," "organosols," "gels,"* or in colloidal suspension. The metals are obtained in this form by well-known methods in a more or less fluid or gelatinous state, which depends, of course, upon the quantity of solvent. The colloidal metals can also be obtained in solid form by careful evaporation of the solvent, or also by drying such precipitated "sols," "gels," or metals in the form of colloidal suspension. In the first case, so much of the solvent of the "sol" or "gel" of one or several of the known metals is separated by evaporation, pressure, or filtration, that a paste is obtained; in the other case, to the finely divided metal is added a small quantity of water, or some fluid which can replace water, such as alcohol, glycerine, chloroform, xylol, and the like. By so impregnating the colloidal metal, the desired paste is obtained.

Such is the new discovery of Kuzel. The treatment of the pasty mass until it becomes a finished filament is carried out in the well-known method. The filament is pressed out of the paste, and dried; since in this form it does not conduct current, it is first heated, and then subjected to a high-voltage current, exactly as we have previously described for the carbide filaments. By heating to a white heat, the colloidal metal changes into the crystalline form. The diameter of the filament and the specific resistance are thereby essentially altered. After heating to white heat, the filaments are ready for use. The colloidal metals, which were previously only applied in isolated instances in medicine, appear, therefore, to be adapted to lead us nearer to the long-desired solution of the problem of economical electric lighting—so at least the experimental results of Kremenecky and others would appear to testify.

The Auer Osmiumlicht Unternehmung have in their latest patent claims only registered for protecting such variations of their methods of manufacture as they have found advantageous in the employment of other metals than osmium. Otherwise, they adhere to their tried paste process. The claim of a patent application made March 15 of last year runs as follows: "Process for the manufacture of filaments for electric lamps from tungsten or molybdenum, without the application of a binding medium containing carbon, brought about by rubbing the trioxide or acid hydrate of these metals with an excess of liquid ammonia to a viscous mass, and then working this up into filaments in the well-known manner."

The many years' experience in the manufacture of osmium lamps, which the Austrian and German Auer-Gesellschaft have at their disposal, stood them, of course, in good stead in connection with their new metallic filament lamps, which they are putting on the market under the designation Osmin and Osram lamps. These new Auer lamps probably contain tungsten as an essential constituent, for this metal appears, up to the present, to have turned out the most suitable of all the metals tried for incandescent electric lighting. The Osmiumlicht Unternehmung, in Vienna, are introducing lamps of 110 volts, which they designate as "Wolfram" (tungsten) lamps. The name Osram lamp also consists of a combination or alloy of osmium and tungsten. While it was formerly supposed that alloys were not suitable for this purpose, on account of the lowering of the melting point, it is now presumed that the new filaments owe their great efficiency not only to the height of the melting point of the metal employed, but also to the fact that alloys, or eutectic metallic compounds, possess characteristic physical properties which are essentially different from those of the component metals. This theory has been propounded by Kuzel.

Graphite Filament Lamps.—For the sake of completeness, something should also be said of the so-called "metalized" carbon filament lamp which has been produced by the General Electric Company by means of a special glowing process. Formerly the carbon filaments were, before their preparation,* strongly heated to incandescence in a suitable furnace. The most important and hitherto unknown changes are shown, however, if the prepared filaments are again heated to incandescence in a suitable electric resistance furnace at 3,000 deg. to 3,700 deg. C. The product of this treatment of the carbon filament, discovered by Howell, was very peculiar. The filaments appeared as if they had been fused by the temperature, and the specific resistance was much decreased. The decrease in resistance, compared with ordinary filaments, amounted at the temperature of the room, to about 80 per cent.

The declivity of the specific resistance was also changed by the temperature in a peculiar way, in that the negative temperature coefficient went over into a positive; so that, by the Howell process, filaments are obtained having metallic properties. In chemical aspect they resemble graphite, and therefore the name "graphite filament lamps" has been chosen for them. The economy so far obtained only amounts, however, to 2.5 watts per candle.

Incandescent electric lighting is still being developed; one discovery gives rise to others, as we have seen. The latest patent applications of Joh. Lux, in Vienna—No. 247,611, of September 8, 1905—also relate to a process for the manufacture of fine filaments for electric lamps from difficultly fusible metals. A further specification by the same inventor was open for inspection on October 15.

* Hydrosol, organosol, gel, and sol are the German terms for distinctive states of colloidal suspension. Reference to these is made later on in this series of articles.

* The preparation consists in bringing a carbonized cellulose filament to incandescence in an atmosphere of hydrocarbon vapor, such as ligroin vapor, whereby carbon is deposited on the thinner, and, therefore, more strongly glowing parts, and the thickness of the filament is made uniform throughout. This outer deposit is supposed to consist of graphite embedded in soot.

CHESTNUT MEAL.†

WE distinguish between the horse chestnut (*Aesculus Hippocastanum*) and the true chestnut (*Castanea vesca*). While the fruit of the latter is very extensively used as an article of diet and as a delicacy, that of the horse chestnut is regarded as only fit for feeding cattle. The horse chestnut has an acrid, bitter taste, which precludes its use as a food for man, but it may be rendered available for feeding animals by extracting with water the bitter principles it contains. By treating the powdered fruit with alcohol, Fluegge produces a gray-white and tasteless food ("Kraftnaehrmittel"). Owing to the high percentage of starch they contain, horse chestnuts are employed for the manufacture of starch and in distilleries. According to Laves, the yield of alcohol obtainable from 100 kilogrammes of horse chestnuts amounts to 25 liters. This alcohol is produced from the carbohydrates and glucosides contained in the fruit.

Very recently E. Laves and A. Fluegge have been granted a German patent for a process of manufacture yielding horse-chestnut meal, which is free from taste, and a starch solution containing the bitter-tasting matters of the fruit. The comminuted nuts are treated to render the starch soluble; the bitter matters and the starch are then separated by pressure from the residue which contains large proportions of proteids and fat.

On the island of Corsica, where chestnut trees abound, chestnut flour is very generally used as a substitute for wheat flour. On comparing the chemical composition of the chestnut flour with that of wheat flour, it is seen that they closely resemble each other. The following are the results of analyses of chestnut meals obtained from different parts of the island:

	Chestnut Meal From				
	Aullène, Per cent.	Zicavo, Per cent.	Campile, Per cent.	Orezza, Per cent.	Bastia, Per cent.
Moisture	12.46	12.32	11.88	11.20	11.78
Nitrogen	6.52	5.95	6.58	6.60	5.82
Fat	2.75	2.75	2.74	2.65	2.85
Sugar and starch	72.88	72.77	72.60	73.83	73.74
Cellulose	2.90	3.87	3.78	3.22	3.96
Ash	2.49	2.34	2.42	2.40	2.85

The ash contains about 32 to 36 per cent of phosphoric acid, a few per cent of chlorides and sulphates, and 8 to 11 per cent of silica derived from the grinding of the nuts. The following figures were obtained in an analysis of selected chestnuts which are used for the manufacture of the meal; the composition of rye and wheat flour are given for comparison:

	Selected Chestnuts, Per cent.	Rye, Per cent.	German Wheat, Per cent.	American Wheat, Per cent.
Moisture	17.9	11.7	14.6	12.5
Nitrogen	7.5	12.2	8.1	11.0
Fat	2.7	1.9	1.2	1.1
Sugar and starch	68.3	82.1	74.1	74.9 (Sugar and starch and Cellulose together)
Cellulose	1.5	1.7	.34	
Ash	2.1	2.1	.6	.5

† Pure Products.

OBSERVATIONS UPON BEES.

THE division of labor among bees is the subject of a paper presented to the Académie des Sciences by M. Gaston Bonnier, who gives the results of his investigation as follows: Last summer I made a series of observations upon this question, which led to some interesting results. It is to be noted that the same bee when working may appear under two different characters. First, when coming to the field from the hive it goes directly to the substance to be gathered and seems to carry out mechanically a predetermined piece of work. In this case the bee is said to be a "worker." The same bee in this instance usually carries out the same kind of work, collecting exclusively the same substance. For instance, if it is collecting pollen, it will not take either honey or water. In most cases, when a bee collects honey on the same species of plant and the latter is in sufficient quantity, it collects only from this species during its trip from the hive. Furthermore, when the bee goes toward different plants or objects whence it expects to secure what it seeks, it is said to be in the attitude of a "searcher." Here the bee flies in a different manner from the "worker," and this difference is quite pronounced. In this case it acts somewhat like a wasp, for the latter insect, which is fairly omnivorous, is nearly always in the condition of a "searcher." We can then observe the searching bee collect both pollen and honey and alight on an object, leaf, or flower, which contains no useful substance. When the bees are in this state they are called "wanderers" by the bee raisers. The same bee is easily changed from the state of searcher to that of gatherer. When it has discovered the proper places, it organizes a troop of bees or gatherers which go to and fro between the hive and the flowers, and the original searching bee also forms one of the party. It is noticed that on a fine day when honey-bearing flowers are abundant, the searchers are much more numerous early in the morning than during the rest of the day, and generally in the afternoon nearly all the bees act as gatherers. On the other hand, when owing to the season, flowers are lacking, the bees which come out are nearly all searchers. Some of them fly around other hives hoping to enter them by the mouth or by a crack so as to carry off some of the honey, and bee raisers call these individuals "robbers."

Among the observations which I made, the following may be mentioned. I already showed that when bees are taking water from a pool in order to prepare the liquid for feeding the larvæ, the bees will ignore floats carrying drops of syrup or even honey, and they do not leave off working to collect it, even crawling over the floats without giving the least attention to the honey. Seemingly ordered to bring water, they will not do any other work, even to take honey. The next day, the searchers had found the honey and organized a party of gatherers which worked upon it, but these were other individuals from the water gatherers. I also made the inverse experiment. During a day late in the season when flowers were scarce, it was found also that there were many water gatherers leaving the hive. Other bees collected honey from one of the rare flowers near the hive. I placed a vessel of water just underneath the hanging branches of the flower bush with cork floats which would have been very convenient for taking the water. In spite of the great need of water in the hive, not one of the bees working on the flowers would collect it, and it was only on the following day that the searchers found the water vessel and led a group of gatherers to it. As they came to take water I marked them by dusting talc on their backs, which adheres for eight days or so. At the end of a certain time no more of them needed to be marked, for they were always the same. But upon the flowers there were none of these bees, showing that they belonged to another party.

Among the numerous observations made on the subject I may cite the following, which shows even better than the former ones how the work is divided among the bees of the same hive, and also a sort of tacit understanding which exists between bees of different hives. Six branches of flowers were placed in as many water bottles and put near the flower bush. After seeing that the bees visited all the flowers, I placed the six bottles in an orchard far from other flowers and remained to observe them. That day there were no bees upon the flowers, but the next day the first searcher bee discovered them. It inspected all the branches and took some honey and pollen, and I marked its back with red powder. After three minutes it returned to the hive. Five minutes after, the first bee (A) came back with another, and both of them acting as gatherers worked upon the different flowers, one collecting honey and the second pollen. The second bee (B) was marked with white. After ten minutes there were three workers, and a newcomer (C) which was marked with green, had come from the same hive, as was subsequently verified. From this time on, the same three individuals worked upon the flowers, A and C always taking the honey and B exclusively the pollen, replacing each other regularly on the branches and visiting them each time in the same order. During all the next day the same bees were found here. Wishing to find out why other bees of the same hive or other hives did not come, I observed the flowers the second day very closely. In the morning other bees acting as searchers flew around them and also observed the working bees, then after two to four minutes' inspection they left and did not reappear; thus it was likely that they considered the place occupied and that the number of bees was enough. The day following, there were no more searchers, and the three bees A, B, and C continued in the

same manner and for the same work as at first. When the number of flower branches was doubled, new workers came on, and the number was about doubled, as there were now seven on the spot, five for the honey and two for the pollen. Then came other searchers, but they soon abandoned as before. These observations, and many others, show how the division of work is carried to the extreme by the bees.

THE LOCATION AND ERECTION OF A 100-MILE WIRELESS TELEGRAPH STATION.*

By A. Frederick Collins.

In the Scientific American Supplement, No. 1605, I described in detail the design and construction of a 100-mile wireless telegraph set, but in order to employ the devices enumerated for sending and receiving messages it is necessary that these should be installed in a suitable place and connected with an aerial wire of proper length and capacity and an earthed plate adapted to the existing conditions.

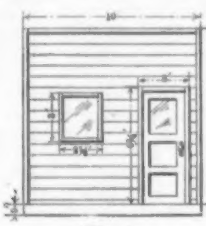


Fig. 1.

Front Elevation of a Wireless Telegraph Station.

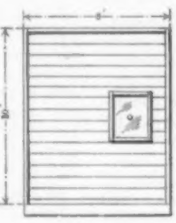


Fig. 2.

Side Elevation of a Wireless Telegraph Station.

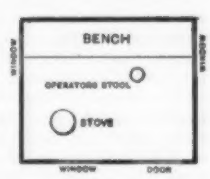


Fig. 3.

Floor Plan of a Wireless Telegraph Station.

The set of instruments referred to was originally ordered to supplant a cable line between an island and the mainland that had a length of 85.5 miles, but it is obvious that this equipment can be installed on board ship equally as well as in shore stations, although in the former case the signaling distance will be cut down somewhat, since shorter aerial wires will have to be used. This untoward feature may, however, be compensated for by using more power. It is advisable wherever possible to use a motor generator if a 110-volt circuit is not otherwise available instead of the primary batteries specified.

The following data relating to the location and erection of a station are the same in any case except that if a motor generator is used to supply the initial energy then a housing separate and distinct from the operating room must be provided. The site selected for the station should be on an eminence as near the water's edge as possible and without intervening structures, trees, or other obstacles in the line of propagation. Very often a building of some kind on or near the site chosen will serve the purpose of a station, in which case the expense will be limited to the cost of the mast and in some instances even the necessity of a mast may be circumvented. A station, however, built for the purpose and isolated from everything else will prove most satisfactory.

A station comprises (*a*) a set of sending and receiving instruments, (*b*) an operating room, (*c*) a mast, (*d*) an aerial wire, and (*e*) a grounded terminal.

(*a*) The instruments are those previously indicated.

(*b*) The exact size of the operating room is not a matter of importance, but it is well to have a floor surface of not less than 50 square feet, although on board ship it is often only half of this amount, while on the other hand where operating rooms are fitted up in existing buildings there is likely to be considerably more room than is actually needed. If a station is to be especially erected the interior dimensions may be 8 feet in width, 10 feet in length, and 10 feet in height. The structure may be set on a wood or brick foundation and may be weatherboarded or allowed to remain with simply the sheeting covering it, according to the amount of money it is desired to spend.

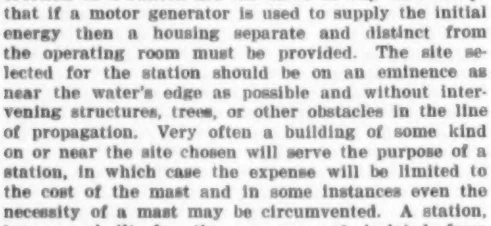


Fig. 4.—The Mast and Its Stays.

A flat roof is the cheapest kind and will serve, if water-tight, the purpose quite as well as any other, though it may not look as well. There should be a large window in at least three sides so that the instruments may be well illuminated. A small vestibule can be built over the doorway with little additional expense and will be a profitable expenditure, as this will prevent the dust and rain from blowing in, both of which are detrimental to the proper working of the apparatus. The interior may be sealed or left plain, while against the rear wall a rigid bench about the height of an ordinary table must be built up for the instruments. Beneath the bench one or more drawers may be conveniently placed and will be found handy receptacles for tools and other appliances needed for the repair and adjustment of the instruments. Fig. 1 shows the front elevation, Fig. 2 the side elevation, and Fig. 3 the plan of the operating cabin. Where the apparatus is installed on board ship the operating cabin may be built on the upper deck either fore or aft between the foremast and mizzenmast, though if expense is a matter of importance, a room between the upper deck and the next one below may be used.

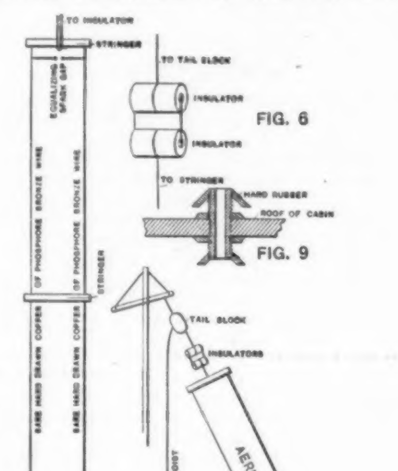


Fig. 5 Illustrates the Leading-in Method. Fig. 6 Illustrates the Insulators. Fig. 7 Illustrates the Method of Attaching the Aerial Wire to the Mast with Insulating Side Block and Hoist. Fig. 9 Illustrates a Hard Rubber Bushing for Leading in the Aerial Through the Roof of the Operating Cabin.

(*c*) Having provided a suitable place for the operating room, the mast follows next in the order of erection, and to insure transmission over the maximum distance the instruments are capable of carrying, the height should be not less than 180 feet. To insure a strong mast, good, clear pine must be selected for the spars or sticks and for masts of this height it is better to use four spars than three.

Where the mast (Fig. 4) is to be built up of four spars the lower spar may have a length of 60 feet and a diameter of 12 inches, the second, or topmast, a length of 50 feet and a diameter of 10 inches, the third, or topgallantmast, a length of 40 feet and a diameter of 8 inches, and the fourth, or royal mast, a length of 35 feet and a diameter of 6 inches. These spars are set in fids or shouldered cross-pieces of wood passed through a square mortise near the heel of the topmast, topgallantmast, and royal mast to hold them in place, their ends resting on the trestletrees of the mast immediately below.

The mast should be sustained by four sets of rigging, although two or three sets will suffice, though the safety factor will not be so large; this must be determined by the position of the mast. The stays supporting the mast may be of hemp rope throughout, or these may be of wire cable with hemp rope terminals spliced in about midway between the ground and the top. The other spars may be guyed out to braces with stays of hemp rope. The braces must be well sunk in the ground and if the mast is erected on a sandy coast it will be necessary to sink the braces to a depth of 15 or 20 feet. A yard, or long, slender spar, nearly cylindrical but tapering from the middle part toward the ends, suspended crosswise from the royal mast and to which a block is secured, completes the structure. Fig. 4 shows the mast complete with every part named so that the foregoing description will be easily understood.

Fig. 8.—Leading-in Method.

The mast should not be placed too far away from the operating room, 50 feet being a good distance, though it may be more or less according to the exigencies of the case. The above, of course, refers to a mast for a shore station; on ships the dimensions for the masts are somewhat different from those given for land equipments, but when wireless apparatus are installed on board vessels the masts that serve to spread the sails are also utilized to support the aerial wires and their method of suspension as well as the different arrangements employed will be shown later.

(*d*) The operating room and the mast having been erected, the type of aerial wire best adapted for the station in question must be considered. The aerial wire indicated in the specifications accompanying those of the sending and receiving instruments previously described called for an aerial formed of a pair of wires each 3/16 of an inch in diameter and 160 feet in length. These wires may be of bare, hard-drawn copper or phosphor bronze, and are attached at the upper and lower ends to a hardwood bar, 14 inches in length and 2 inches in diameter, and should be separated from each other 10 inches, while a similar bar midway between those at the ends will keep the wires from coming in contact with each other, as shown in Fig. 5.

In the middle of the upper hardwood bar a tarred hemp rope is looped around a large cylindrical glass or porcelain insulator having a groove cut circumferentially around it. A second insulator of the same size is also similarly provided with a hemp rope and the two insulators coupled together by drawing the ends of a short length of tarred rope through the apertures of the insulators and splicing them together, all of which is brought out clearly in Fig. 6. The free end of the rope is then run through a tail block made fast to the end of the yard, which may be hung square or lateen, that is, obliquely to the mast. The rope is brought down to the bottom of the lower mast, where it can be made fast and so serves as a hoist for the aerial, by means of which it can be raised or lowered, as illustrated in Fig. 7, should necessity require.

The lower end of the aerial wires are twisted together and soldered to a length of about 15 feet of insulated copper cable having a diameter of about ¼ inch. To prevent leakage of the high-tension energy that surges through the aerial in the form of electric oscillations, the "rat-tail," as this portion of the aerial is termed, leads through a glass, porcelain, or hard rubber bushing into the station where it is connected with the aerial switch.

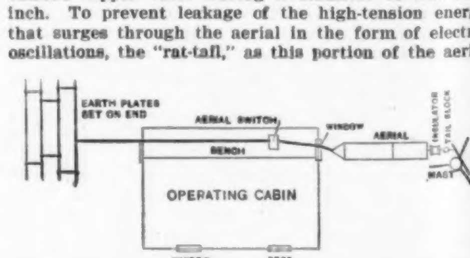


Fig. 10.—Ground Plan of a Complete Wireless Station.

The best method of insulation is to cut a hole ¾ inch in diameter in the window pane, insert the bushing in this, and draw the rat-tail through it to the inside. On board ship and in stations that have not been especially designed for the purpose, a window is not always located in such a position that the end of the aerial can be made to pass through it conveniently, if at all, and make connection with the instruments, as shown in Fig. 8. When this untoward condition is met with the alternative is to use a bushing of hard rubber, the walls of which should be at least one inch in thickness and fitted with petticoats on

*Specially prepared for the Scientific American Supplement.

the end, as illustrated in Fig. 9. In this case a hole is bored through the roof or the wall of the operating room and the bushing with the upper petticoat pushed through from the outside when the lower petticoat is screwed on as shown. The rat-tail is led through the aperture of the bushing, when it is connected with the aerial switch of the sending and receiving instruments as before.

In installing an aerial wire for wireless telegraphy it must be constantly borne in mind that a high insulation of every part where it comes into proximity with objects of whatever nature is of the greatest importance, especially in long-distance transmission, since material of every kind that not only touches but merely approaches the aerial aids in the loss of energy that would otherwise be available for radiation. Fig. 10 shows the ground plan for a complete wireless station.

While aerials suspended by masts on shore stations usually are permitted to hang at as slight an angle from the vertical as possible and yet clear the stays, on board the ships in the navy the wires are brought down at the angle shown in Fig. 11, the operating room being generally located abaft the mizzenmast. Wherever the aerial wires are likely to come into contact with the spars of the other masts hard-rubber insulators are provided, as indicated in the illustrations.

On ships in the merchant marine service the aerial wires are often given the form shown in Fig. 12. Usually two wires are stretched horizontally between the foremast and the mizzenmast and to the middle of these two, wires are connected and brought down vertically to the operating room.

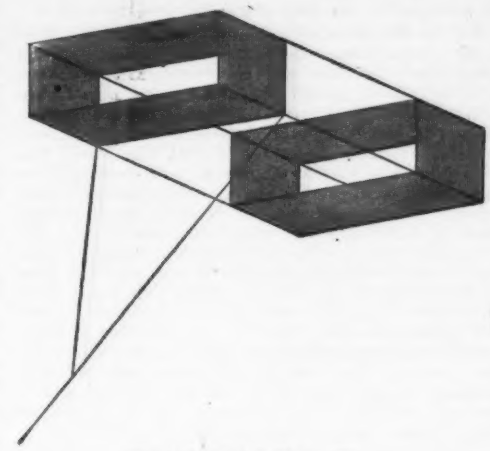


Fig. 14.—Blue Hill Box Kite.

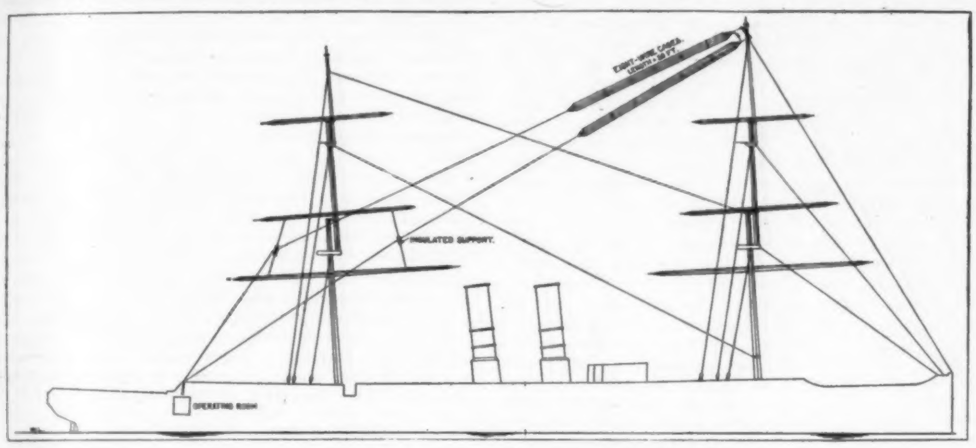


Fig. 11.—Aerial Wire Arrangement on the U. S. S. "Topeka."

(*c*) The successful operation of a wireless telegraph system depends almost as much on a good earth as on a properly-insulated aerial. To secure a good earth is not always an easy matter, even in the vicinity of the sea, unless the metallic plates can be anchored in the water. If the station is so situated that the grounded terminal has to be buried in the earth, then a hole must be dug deeply enough so that the earth is always moist; and if a moist earth cannot be had then a much larger surface of metal will be required.

Sheets of copper or zinc may be used, and although the former gives the best results per unit of area exposed, yet the latter is much less expensive. For a station on shore using a 100-mile set of instruments the metal plates should have not less than 150 square feet of exposed surface. The plates are prepared by cutting the roll into sheets having 12 or 15 square feet of surface and soldering these together with strips of the same metal, about 4 inches wide and 12 inches in length, forming a rectangle.

To the various plates making up the grounded unit strips of the same metal are soldered, and these must be long enough to project above the surface of the earth, where they are brought together and where a small cable leading to the aerial switch is secured to them. The plates can be placed either horizontally or vertically in the ground, the former being the arrangement most frequently used, since it is the easiest, as the hole need not be so deep.

Occasionally it will be found difficult to get a good earth, and when such conditions prevail it is considered good practice to have separate earth plates for the sending and receiving apparatus, and when this means of grounding is resorted to, the aerial switch is arranged to cut out the earthed terminal of the microphone detector when sending. On board ship the difficulties of providing a good ground are reduced to a minimum, for all that is needed is to connect the earthed terminal of the instruments to a pipe or other metal parts that are in connection with the hull of the ship. It is not necessary to insulate the wire leading to the earth from the woodwork of the operating room, for this part of the station is an integral part of the earthed system, resting as it does on the ground.

The above instructions provide for the erection of stations either on shore or ship, but should there arise an occasion when it is desirable to use the instruments for field work, that is, for portable stations, then the masts and embedded earthed terminals may be eliminated from the equipment and kites and surface grounds can be utilized instead.

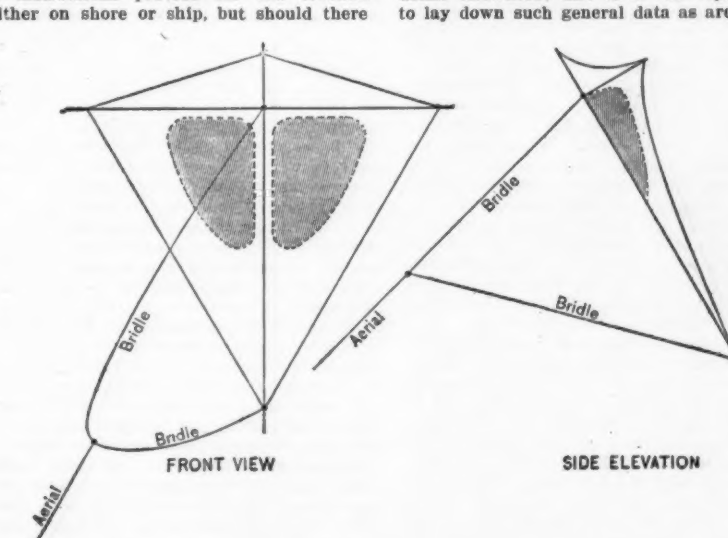


Fig. 13.—Eddy Tailless Kite. Shaded Portions Represent Pockets for Wind.

This latter arrangement is very convenient for experimental and other purposes where portability is an object and the instruments may be transported on a light spring wagon and set on a table when they are to be used. An aerial wire to be elevated by a kite may be of No. 14 steel, copper, or aluminium wire and have a length of 500 or 1,000 feet. This is wound on a reel and attached directly to the bridle of the kite and serves, at the same time, in the place of the usual kite string. This is a much better plan than to use a lighter wire for the aerial which is attached to a kite string, for the latter permits much of the energy to be dissipated by leakage down the string.

The kites best adapted for elevating aerial wires are those of the tailless type. The Eddy kite flies in a light breeze and its construction is shown in Fig. 13. The kites are made in various sizes but one 6 feet in height will be found best adapted for elevating the wire; if additional lifting capacity is desired two or more may be connected in tandem. A kite that will fly in a wind having a velocity of 30 or 40 miles per hour is shown in Fig. 14; it is known as a box kite and, like the one previously described, it is tailless. These kites have loops of string, or bridles, attached and to these the kite strings or aerial wires are secured.

The earthed terminal for field work need not be grounded by embedding a metal plate in moist earth. The terminal to be earthed is soldered to a long length of wire netting and this is spread out flat on the grass. The blades of grass make a very good connection with the earth, for these are conductors, and being rooted in the damp soil underneath, a good ground is assured. Messages have been received with the microphone detector attached to a 1,000-foot aerial a distance of over 400 miles.

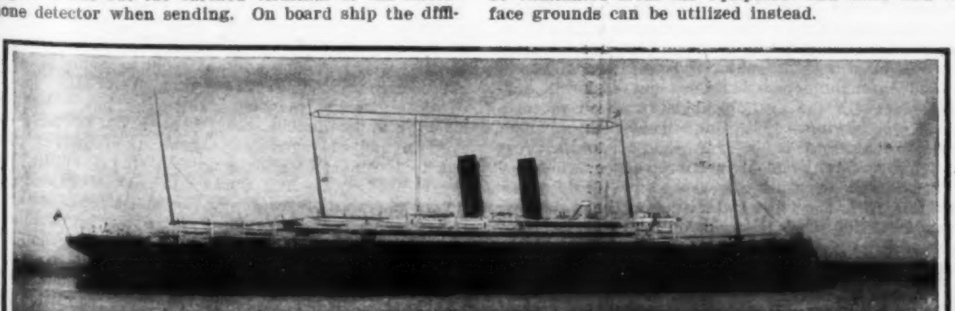


Fig. 12.—Aerial Wire Arrangement on the "Baltic."

SOME CONSIDERATIONS AFFECTING THE APPLICATION OF WASTE GASES FOR POWER PURPOSES.*

By F. E. Junge.

While it is generally conceded that the various artificial gases which are available for the generation of power, such as blast-furnace, coke-oven, and producer gases, must be cleaned in order to enable the prime mover to perform its service not only at a high degree of thermal excellence, but also continuously and without breakdowns, it is not always obvious by which means the different gases can be cleaned most economically—that is, with as little expense for power, water, and labor as possible; also what is the effect of gas cleaning on the efficiency of gas-fired boilers, gas engines, piping, etc. Further, very little knowledge has been propagated on such questions as: What is the best use that can be made of the gas inside the plant, and which is the most profitable way of utilizing the surplus quantity outside?

I have treated of the first part of the problem in detail elsewhere† and it is the object of this article to lay down such general data as are available on the latter application. It is obvious that with three different kinds of gases available, which show different characteristics, i.e., heat value, composition, temperature and impurities contained, not only relatively to each other, but each in itself at different times within comparatively short periods, the selection of the particular application to which each gas is best adapted is a matter of no little consideration and consequence.

BLAST-FURNACE GAS.

Speaking more particularly of the utilization of blast-furnace gas in the iron and steel industry, which affords, indeed, the most complete exemplification of all the conditions which affect the operation of a gas power plant, it is known that for various well understood reasons blast-furnace works are preferably combined with steel-smelting plants and rolling mills in order to be able to carry out the entire series of converting and finishing processes which transform the original ore into marketable steel products, all under one ownership and with maximum industrial economy.

* From Power.

† The Cleaning of Blast-furnace Gas, The Iron Age, September, 1906.

There are several distinct uses to which blast-furnace gas can be put in works of this magnitude, and the soundness of judgment exercised by the designer of the plant in the distribution of such uses will determine, on the one hand, the amount of additional solid fuel that is consumed in the plant in the form of coal or coke and that must be supplied by the works management at extra cost, and, on the other hand, the available surplus power that may be sold to advantage in the neighboring districts or cities, and which will yield remunerative returns in addition to the savings effected within the works.

The question whether the gas that is produced in the blast-furnace plant is better utilized for the production of heat by firing (besides the hot-blast stoves) open-hearth and other furnaces, or for the generation of motive power in driving blowing engines, rolling mills and central stations, can only be decided after a careful consideration of *all* factors which determine the commercial economy of a plant of this character. Thus we must primarily analyze the relation of the utilization coefficient of the first application, i.e., gas used for heating purposes, to that of the second, i.e., gas for producing power. In some instances, as with the heating of the hot-blast stoves and the driving of blowing engines, the values of the utilization coefficient and load factor are practically identical; but in others there may be considerable difference. So it will often be found that the utilization coefficient of gas for motive power cannot be estimated higher than from 60 to 75 per cent, while the corresponding item of gas for heating purposes may run as high as 85 and even 90 per cent. This difference is naturally founded on the intermittent working of the power plant with its auxiliaries, the various accessories, like pumps, hoists, fans, etc., showing together an extremely fluctuating load curve, while the various furnaces work almost all day and night, consuming gas at a nearly constant rate.

The analysis must further embrace a careful comparison of the intrinsic values of the respective fuels which are displaced by the utilization of blast-furnace gas. Thus, if blast-furnace gas is used for raising steam, it displaces coal of inferior quality, while when it is used for firing furnaces it displaces gas coal of higher intrinsic value; and though it is difficult to estimate accurately the gain in favor of the latter utilization in exact figures, it must be conceded that in some cases such application will increase the working efficiency of the plant.

Moreover, there is to be determined whether the lower first cost of the heating appliances against those of a motive-power equipment is a decisive factor in favor of the former application, or whether the far superior efficiency of energy transformation in the latter method is of weightier commercial bearing.

GAS AVAILABLE FROM COKE OVENS.

In some special cases, namely, when coal mines are located so near the works that they fall into the commercial distribution radius of the combined iron and steel-smelting plant, this part of the problem becomes even more complex, since of the total quantity of gas produced in coke ovens about 60 per cent is used to heat the retorts, 10 per cent to drive the various appliances of the coking plant—such as washers, pumps, etc.—while about 30 per cent of the gas is available for outside purposes. Now, the relation of the respective intrinsic values, embracing heat contents, cost of generation, transmission, and cleaning, of coke-oven versus blast-furnace gas, must be analyzed, since it may be found advisable to heat the steel furnaces with coke-oven gas of high calorific value instead of with the weak blast-furnace gas, thereby saving the cost of regeneration of the gas and having only regenerative ovens for the air supply, similar to what obtains when natural gas is employed for such purposes.

Assuming a consumption of only one ton of coke per ton of pig iron smelted, there is needed for a production of, say, 1,200 tons of iron a day, 1,200 tons of coke. Figuring on an efficiency of transformation of 76 per cent, 1,580 tons of coal are needed for making that coke. The total quantity of gas generated per ton of coking coal averages 28 cubic meters (988½ cubic feet), so that 442,400 cubic meters (15,623,000 cubic feet) of coke-oven gas are produced within twenty-four hours. This, of course, is only an assumed amount, since in modern by-product ovens the quantity of gas produced depends on the quality of the coal coked, on its moisture contents, and on the type of oven, and varies considerably in composition during one coking period. In the latest regenerative ovens of the Otto type up to 140 cubic meters (4,840 cubic feet) of gas per ton of coal coked are attained, the gas consisting chiefly of CH_4 and H, and having a calorific value of about 4,000 calories per cubic meter (448 B.T.U. per cubic foot). About 60 per cent of this is used for heating the retorts, leaving 40 per cent for other purposes. This gas has a calorific value of 500 B.T.U. per cubic foot and some 25 cubic feet per hour of it, when burned in a gas engine, will develop one horse-power. The total available energy of such a plant would therefore be 10,500 horse-power. Of this amount about 10 per cent is used for driving plant auxiliaries, leaving 9,500 horse-power available for sale.

If the coke ovens are located near the steel works the gas may be used in the works for heating steel furnaces, as stated above. In a plant of the above capacity this would mean 1,836,360 cubic feet of coke-oven gas displacing 43 tons of good coal and absorbing one-third of the total surplus quantity of gas available (5,650,000 cubic feet). Without deducting the amount for the above application, there is for every ton of coal transformed to coke in twenty-four hours 6 horse-power available for other uses.

PRODUCER GAS.

Nor is this question nearly settled with the foregoing considerations, since in combined plants of this magnitude there are still other resources available, such as inferior grades of coal from the mines, culm piles, etc., which, though hitherto wasted, can now by the application of up-to-date methods be fully utilized for the economic generation of heat and power gas, in addition to what is gained as a by-product from the blast furnace and coke oven. Such practice is now finding universal adoption in Germany, since several years of experience with the Jahns type of ring producer and other systems have proven its practical merits beyond discussion. A plant of this kind has done active service in the Von der Heydt coal mines since April, 1903, which is a sufficient time for drawing definite conclusions as to results. The fuel used is slack, residue and refuse which drop from the coal conveyers and tipplers; also culm banks, which were formerly wasted. It only contains 20 per cent of coal and is now fed directly to the producers. In this way 2,100 tons of waste material are gasified, giving a total of 14,000,000 B.T.U., or 3,245 B.T.U. per pound. The cost of 1,000 B.T.U. is 0.005 cent.

Of the heat developed, 13,650,000 B.T.U. are used to generate 3,500 tons of steam. One ton of steam from gas-fired boilers costs, therefore, 20 cents for fuel, as against 44 cents from coal-fired boilers, as a certain quantity of steam coal has to be supplied in addition to the waste in order to meet the demand. Part of the gas is used in gas engines for the generation of electric power. The cost of the gas per brake horse-power hour, assuming a consumption of 9,750 B.T.U., comes out as 0.05 cent. The steam cost per brake horse-power-hour in steam engines is found to be 0.51 cent when steam is raised in coal-fired boilers, and 0.24 cent when it is raised in gas-fired boilers. Figuring on an average consumption of 10,000 B.T.U. per hour per brake horse-power in gas engines, and deducting losses through natural deterioration of the fuel, it can be taken that one ton of culm generates in modern producers from 20 to 25 horse-power for twenty-four hours.

It is by combinations of such character and magnitude that the iron industry affords the most striking and comprehensive field for the application of gas power from a variety of sources and for a multitude of purposes. Indeed, leaving aside natural gas, which, owing to its territorial and quantitative limitations, cannot claim consideration in this discussion, we find all the principal sources of commercial gas generation, namely, the blast furnace, the coke oven, and the producer, as well as all forms of transmission, namely, heat, light, electric energy, and mechanical power, and their modes of distribution, represented and combined in this one field. Therefore, economic considerations, commercial questions, and technical research on the production and utilization of gas may always be based on the iron industry as the most fitting subject for such studies.

RELATION OF NATURAL GAS TO WASTE GASES.

It was said above that natural gas cannot claim consideration as a fuel for large-scale operations in the iron and coal industries. This, of course, refers only to future activities. When natural gas was first discovered and brought into practical use there seemed to be the general idea that the supply was inexhaustible, and it was sold at low rates and usually without measurement. This method encouraged waste in the consumption of natural gas and was only abandoned after the large companies had obtained control of the business. But the gas which was wasted in the early period of production cannot now be regained by recourse to economic methods of distribution and consumption.

As far as the present production of natural gas is concerned, the increased value in 1905 ($41,562,855 compared to $38,496,760 in 1904) is recorded by the U. S. Geological Survey to have resulted from a general advance in price rather than from any increase in yield. As a matter of fact the great gas fields of Indiana and elsewhere have shown a steady decline since 1902, and the value last year was considerably less than one-half of the maximum production. And even conceding that in several States large and prolific gas fields are being opened up, this would not be of much consequence to the iron and coal industries as consumers of gas power, who must have a definite guarantee that the supply of fuel on which the constancy of production is founded will be upheld for an indefinite time, in unchanging quantities, and within the commercial distribution sphere of their works.

Where natural gas is available as a by-product of the property owned by some manufacturing concern, or where it can be had in the immediate vicinity of a plant, then it goes without saying that it will be used, provided that it can be bought at a reasonable price. It may even be pumped over long distances provided that this operation does not make it noncompetitive with the available blast-furnace and coke-oven gases. Owing to its high heat value, which ranges from 900 to 1,000 B. T. U., and to its great heat density, it is the ideal fuel for transportation, being greatly superior to coke-oven and blast-furnace gases, especially the latter, which has a thermal value of only 90 to 100 B. T. U. per cubic foot.

A further advantage is that no additional expenditures for cleaning have to be charged against natural gas, when burnt in gas engines instead of under boilers, while with blast-furnace gas a part of the cost of cleaning and with coke-oven gas the total amount must be charged against it in addition to the price at which the works management appraises the different "waste" gases. For, when heating boilers, coke-oven gas need not be specially cleaned and yet will give better results that the weak blast-furnace gas, which must be purified and freed from dust in order that the results attained may be similar to those with coal-fired boilers.

Thus the merits of gas power versus steam power, which will be discussed presently, are less pronounced in collieries where coke-oven gases are available. This is partly due to the fact that the cost of power generation represents not nearly so large an item as it does in iron and steel works, since, unless distribution to neighboring districts is provided or very unfavorable conditions prevail, not more than four to five per cent of the total quantity of coal produced (or its equivalent in form of waste heat or waste gases) is required in the mines, provided they are equipped with modern economic power plants. It is also partly because in contradistinction to steam drive, the coke-oven gas engine must be charged with the total cost of gas cleaning, in addition to the price charged for the gas as produced. The latter valuation depends entirely upon local conditions. It is sometimes based on a rate corresponding either to a certain weight of coal of thermal equivalence, the price of which in turn depends on whether it is purchased from other or from one's own mines, or to the amount of steam that can be generated by a certain measure of both fuels, or to that of some other standard of comparison.

In any case the valuation of what is called waste in industrial pursuits is nowadays a matter of no mean importance and is not determined and dependent on purely theoretical and technical considerations, but on practical economic questions which have a decided bearing on the remunerative returns of the capital locked up in the different branches of a large industrial concern.

Summing up, it was said that natural gas is an ideal fuel for heating furnaces, raising steam under boilers, and serving to operate gas engines. The fact that over 100,000 horse-power are generated in gas engines running on natural gas in this country is a better proof of its adaptability to that use than any other argument. But against all these advantages there stands the other fact that the production of natural gas is on the decline, while the demands for gas power are increasing daily. Therefore it is safer to base our claims for future activities on coal as the energy-supplying fuel, since it is certain that the annual production in this country of nearly 400,000,000 tons can be kept up for hundreds of years to come.

UTILIZATION OF AVAILABLE POWER GAS.

Now coming back to our discussion of the principal conditions which determine the commercial and technical distribution of these various gases within the works, a new problem presents itself. After having decided to apply a certain quantity of a certain gas to the production of motive power, the other no less important question arises whether it is more advantageous to use the gas under boilers for steam raising and to employ steam turbines in the central station, or whether it is more economical to burn the gas directly in gas engines, the points in favor of the first equipment being lower first cost, smaller floor space, less expenditure for up-keep, and no difficulty to secure skilled labor, while the advocates of gas power advance arguments of no less weight, namely, elimination of the wasteful and costly boiler equipment with its danger of explosion, smoke nuisance, etc., and reduction of operating cost to one-third of the cost of steam drive.

Since earnest and laudable efforts have recently been made on the part of gas-engine manufacturers to reduce the first cost price per unit of output to the level of steam-engine costs, and since the only difference between the two forms of application consists in the employment with gas power of a cleaning plant as substitute for the boiler equipment, the whole controversy resolves itself into the very simple requirement to provide for a gas-cleaning plant, which is superior in economy, as regards first cost, floor space, water consumption, and skilled labor, to a steam-boiler plant of the same capacity. But even this is no longer a correct argument, since it has been found that in order to get the highest plant efficiency with steam the gas for boiler heating must be brought to almost the same degree of purity as when burnt in gas engines. This will be discussed later. All other objections are insignificant compared to the simple fact that by the direct utilization of the gas in gas engines, power can be produced at one-third of the cost that is on record for any other form of power generation.

When iron works and coal mines are located in the neighborhood of other industrial centers, communities or cities, and provided they have a sufficient amount of salable surplus power available, the works management is confronted by another problem, namely, to decide which system shall be adopted for the supply of these outside markets. They can have the gas-cleaning or by-product recovery plant put up near the furnace and at their own expense, and deliver pure gas to the power station or works to be supplied, or the owners of the iron works and coal mines can put up the cleaning or recovery plant and a complete electric power station, which may, of course, be combined with the central station of the works, and sell the electric energy to the supply company or works at so much per unit. Which of the two methods is the more advisable to adopt depends entirely on local conditions.

The foregoing reference to the power question was made in order to show, by a careful analysis of the actual conditions prevailing in the iron and coal industries, what significance the factor of gas cleaning

possesses in the general problem of securing maximum industrial economy from the utilization of blast-furnace and other available gas. With certain limitations the same line of thought commends itself also for the design and operation of collieries. But, leaving a detail discussion of the latter application for later consideration, I shall first attack the subject from a different point of view, and one that will embrace the enumeration of practical advantages gained by the adoption of efficient methods of gas cleaning in such plants, as well as the cost of gaining them.

CLEANING IS REQUIRED FOR HEATING AS WELL AS FOR POWER GAS.

It was stated in an earlier part of this article that there was until a short while ago very little actual experience available on the matter of gas cleaning, and that it was held by eminent authorities that if the larger part of the gritty dust contained in the blast-furnace gas were removed in the dry-dust catcher the remainder would not prove harmful to the stoves, boilers, and engines to which it was supplied. It was also maintained that the gas should never be washed for boiler heating, as any tarry products it might contain would enhance its heating power by increasing the luminosity of the flame. Furthermore, there was the seemingly weighty argument submitted that the cost of cleaning the gas, together with the increased plant floor space, were apt to annul the advantages gained from the superior heating properties of the cleaned gas.

Consequently, in the first attempts to utilize the waste gases from blast-furnace plants the hot gas was delivered directly to hot-blast stoves, steam boilers, and furnaces laden with dust and at a temperature of from 140 to 160 deg. C. Needless to say that with such practice it was necessary periodically to shut down the boiler plant for cleaning the settings, besides the cleaning that was ordinarily done as a part of the daily routine of the works, and that the frequent cooling of the boilers subjected them to heavy strains, which greatly impaired their efficiency and necessitated frequent repairs. Furthermore, the heating surface of the boilers would gradually decrease on account of the dust that settled down at a cumulative rate, thereby requiring a constantly increasing quantity of gas for generating the same amount of power.

The lower heating value of uncleaned blast-furnace gas per unit of volume, and its inferior combustion efficiency when containing considerable quantities of fine dust, would anyhow necessitate a larger grate area of boilers, the difference compared to the employment of clean gas running as high as 10 per cent. At the Cockerill works in Seraing, Belgium, it was found that after cleaning a boiler and putting it into commission again it required with dirty gas three hours' time to get up the steam pressure, while by using clean gas this time could be reduced to one and one-half hours.

A. Gouvy records a case established by actual measurements where, with a freshly cleaned fire-tube boiler, the consumption of blast-furnace gas amounted to 1,925 cubic feet per pound of water evaporated, while after a fortnight's operation the consumption increased to 3,529 cubic feet, or almost double the amount. This increase is explained by the dust accumulating in the fire tubes and forming a thick coating over the heating surfaces of the boiler. It was also shown by experiment that the cleaned gas effected a larger evaporation per unit of heating surface with less consumption.

In hot-blast stoves of the Cowper type the cost of up-keep is not a very important item of expense, since even at present their internal structure can be maintained in good shape for three years and longer. What the cleaning of gas does in this instance is that the heat-radiating capacity of the fire brick is greatly increased, since it is no longer covered with dust and slack, so that with the same quantity of gas higher blast temperatures can be attained and a great saving in coke consumption effected.

Gouvy's experiments prove that for the higher temperature limits of from 650 to 900 deg. C. an increase of the blast temperature by 100 deg. will save from 110 to 165 pounds of coke per ton of pig iron produced. For the lower limits this saving is even higher and runs up as high as 220 pounds per ton of pig iron smelted. Assuming the price of coke to be $3.60, the cleaning of the gas would effect a reduction of the cost of production of pig iron by at least 18 cents per ton, if the temperature of the blast were increased by 100 deg. C. A blast-furnace plant working with very high blast temperatures, such as from 850 to 900 degrees, will, of course, be unable to effect a saving in the above sense, but the cleaning of gas enables one to use less gas in the hot-blast stoves and to employ the resulting surplus for heating boilers, which again results in a reduction of the coal bill. At Dommeldingen, Germany, the employment of cleaned gas for heating Cowper stoves has effected a reduction of coke consumption, in consequence of the higher temperatures attained, representing an annual saving of $8,600 for one 100-ton oven.

All these deficiencies of operation, and more especially the considerable amount of manual labor that had to be expended for removing the dust, have served to convince the designers of gas-power plants that it is more economical to clean that portion of the blast-furnace gas which is used for raising steam under boilers, but then again it was maintained, for reasons which cannot very well be defined, that it was unnecessary to extend purification to that other part of the gas which is used for heating the blast. Yet it is clear that the same line of thought that leads to the cleaning of the boiler gas must also bring about similar advantages when extended to the gas heating the blast stoves.

Thus one of the stoves which is now installed to serve as a spare unit for reserve, in order that the capacity of the furnace may be maintained during the period of cleaning of the different stoves, may be done away with entirely, thereby saving considerably in the first cost of the installation. Smaller heating surface, superior combustion efficiency, and higher temperatures in the blast stoves, besides the saving in labor for removing the dust, are some of the other advantages gained. Depending on the design and capacity of the stoves, the percentage of moisture contained in the air, the intensity of radiation, the quality of coke charged with the ore and the composition of the latter, and on the degree of purity of the gas, it is possible to reduce the quantity of gas supplied for heating the blast to from 25 to 18 per cent.

VARYING QUALITY OF BLAST-FURNACE AND COKE-OVEN GASES.

One more point, which comes up when studying the physical and chemical properties of blast-furnace gas as an energy-transforming medium, is deserving of consideration, namely, the varying quality of the gas at different stages of the generation process. While the average thermal value of blast-furnace gas lies between the limits of from 100 to 106 B. T. U. per cubic foot, and sometimes even reaches higher values, it often drops down to 90 or 85 B. T. U. per cubic foot in the course of one day's operation. In coke-oven practice the composition of the gas changes even within wider limits. Owing to the working process of the standard type of four-stroke cycle gas engine, the output of which is rigidly limited by the cylinder suction capacity, the power plant, even when equipped with ample gas storage, is unable to sustain peak loads for any length of time while the energy of its working medium is thus widely fluctuating.

Though the automatic gas-supply system which has been introduced by the writer in the design of such plants eliminates this trouble of inflexibility of engines by providing between the source of gas generation and the prime mover an elastic member, preferably a fan running at variable speeds, with its output automatically regulated from the governor of the engine according to the momentary requirements, thereby securing flexibility and overload capacity similar to steam drive, it is yet desirable that regularity and uniformity of the conditions which affect the working of the furnace directly be likewise maintained. Therefore, if the varying composition of the blast-furnace gas is uncontrollable, the maintenance of a constant degree of purity of the gas used for heating the blast, as well as the permanent efficiency of the heating surface of the blast stoves, is imperative, as these features increase the working efficiency of the plant. For it must be remembered that all these various niceties of operation help to reduce the amount of manual labor that has to be expended, as well as the quantity of gas required for generating heat and power to carry out the long series of reducing, converting, and finishing processes, thereby eventually decreasing the coke consumption per ton of pig iron smelted, and hence also the total cost of production.

EFFECT OF GAS CLEANING ON COST OF INSTALLATION.

Another factor which has hitherto not been fully appreciated is the influence of the reduction of temperature and volume of the gas, which is effected by the cleaning process, on the capacity and first cost of the installation and also on the cleaning process itself. Consideration of the temperature-pressure relations of a gas, or better the ratio of the increase of density to the decrease in temperature, will show that the gain effected by a reduction of temperature of 100 deg. C. is represented by a contraction of the gas to one-third of its original volume. Now it is obvious that the capacity of an apparatus wherein the gas is transformed by combustion into heat or power, or in which it is washed or mixed or moved, will be increased in a similar ratio while the efficiency of such processes also becomes better. Therefore, to secure a reasonable degree of engine capacity with blast-furnace gas, which is by far the leanest of all commercial gases, it is necessary to reduce its temperature to some 25 or 30 deg. C. This is, of course, also dictated by other conditions, such as danger of premature ignition, etc.

The range of temperature reduction in blast-furnace work is from about 150 deg. C. to about 25 deg. that is, a reduction of about 125 deg. C., and it can easily be computed what shrinkage is effected by such cooling; also what the effect of the contraction is on the size and dimensions of the conduits, pipes, and channels used for conveying the gas. The latter point is further emphasized by the fact that the gas-cleaning plant delivers the gas to boilers, engines, and stoves under a pressure of from two to four inches of water, depending on the kind of fan or blower employed, thereby further reducing the bulk of the distributing means and the first cost of the installation.

The foregoing enumeration of reasons may suffice to prove the necessity for subjecting the whole quantity of gas generated in blast furnaces, coke ovens, and producers to thorough purification before utilizing it for heating blast stoves or furnaces, for raising steam under boilers, or for generating mechanical or electrical power in the central station.

COST OF GAS-CLEANING EQUIPMENT.

In order to give some idea of the additional expense introduced by the installment of a modern cleaning plant of the high-speed centrifugal type, the following data from European practice are presented, all items being based on 1,000 cubic feet of gas. The initial capital outlay is $26 for heating gas and $39 for power gas, not including pipe connections, clearing ponds, water pumps, gas holders, and similar accessories. The power for moving the gas and pumping the water is 0.15 horse-power for heating gas and 0.27 horse-power for power gas. The consumption of cooling water per hour is 31.2 gallons for heating gas and 46.4 gallons for power gas, the temperature of the water varying from 5 to 35 deg. C., according to the season. The cost of operation for plants in use 365 days in the year and 24 hours daily, figuring on the horse-power as costing 0.25 cent, and ignoring the value of the blast-furnace gas and amortization, but including regular attendance, oil consumption, repairs, and up-keep, in German practice comes out 0.04 cent for heating gas and 0.072 cent for power gas. With the above a degree of purity of one grain of dust per 1,000 cubic feet of gas for use in gas engines can be attained.

THE OUTSIDE DISTRIBUTION OF POWER.

A reference was made in the above to the distribution of the surplus power from iron and steel works and collieries to neighboring districts. The most desirable means of long-distance transmission is, of course, electric current, though serious propositions have recently been made to pump gas from the coal-fields over long distances to cities, to be there used for heat, light, and power purposes in competition with the existing gas companies. Of the available artificial gases coke-oven gas is superior to blast-furnace gas for transmission, owing to its greater heat density. In oil regions the employment of oil gas is going to be a factor in competition of no mean importance.

The surplus power, which remains available after deducting all requirements within the works may be utilized in various ways. The most feasible and the one most often used is to deliver light and power to communities or cities located in the immediate vicinity of the plant. Where these natural outlets are not available, it is becoming more and more customary to establish a system of power exchange between such works as are located within a certain commercial distribution sphere relatively to each other, the object being to save in initial and operating cost of plants, to balance the stability of output by a corresponding provision for consumption; in other words, to obtain a constant high-load factor for the combination of works, and last, but not least, to provide for a common and ample source of energy in cases of emergency.

Thus small coal mines which produce good coal for coking purposes, and have sufficient coking capacity, will install a coke-oven gas power plant which, besides furnishing energy to these mines, distributes electric power in form of high-tension electric current to neighboring mines at a profit, or they will make an agreement with some central electric station to deliver a certain amount of energy at a certain figure all the year round to the said station, whence it will be sold and distributed to consumers at a profit. Since the central station holds similar contracts with a number of individual contributors, and since the agreement provides that in case of a break-down any contributor may become a consumer, that is, may take energy for emergency uses within his works from the line, it is evident that this arrangement offers an ideal means of making and selling energy under economic conditions profitable to all alike over wide territories, provided that the respective concerns can persuade themselves that a combination of such mutually beneficial character does not preclude competition.

The saving effected through these combinations is due, on the one hand, to the elimination of special power generating units and costly reserves; on the other to the maintenance of a constant high load factor. The importance of the latter item will be appreciated when it is considered that in some gas power plants an increase of the load factor from 25 to 50 per cent will halve the total cost of power.

For the practical realization of reciprocal policy we must again turn to Germany, where, owing to the close concentration of industrial centers, most headway has been made in the centralization of power. In a recent paper on the production and utilization of power in metallurgical and mining pursuits Dr. Hoffman, of Bochum, discusses quite a number of such combinations, of which the one covering part of the territory of Rhenish Westphalia is the most interesting, because it is the largest of its kind up to this date.

The price paid by the Rhenish-Westphalian Electric Central Station to the various iron-smelting plants and collieries for their surplus energy is 0.7 cent per kilowatt-hour. Owing to its own large power plants, aggregating about 55,000 horse-power, and to the fact that it can save the reserves, it is possible to sell energy at a very low rate.

For instance, to large consumers, such as factories, rolling mills, etc., the charge is 1.4 cents per kilowatt-hour, and for driving motors which run at a constant high load factor, such as fans for mine ventilation, the charge is as low as one cent. This central station has also made contracts with several communities and cities, and has taken active part in the operation of smaller central stations and of electric railroads running through the commercial distribution sphere of their works. The tariff rates are based on a sliding scale, beginning at 7.6 per kilowatt-hour for light, and 3.5 cents for power, and decreasing in proportion to the consumption to 3.5 and 1.4 cents respectively.

Similarly those collieries which transform a considerable portion of their coal output to coke, are selling their surplus energy to neighboring districts. The largest German coal mine, "Rheinpreussen," will shortly produce 3,000,000 tons per annum, of which one-

third is to be coked. With this amount at least 17,000 horse-power is generated in gas engines, while only 10,000 is used in the collieries. The surplus energy is sent in form of electric current at 10,000 to 20,000 volts, to the city of Krefeld and its new Rhein harbor, where it is transformed and sold at 1.9 and 1.7 cents per kilowatt-hour respectively.

Another and very promising way of disposing of the surplus energy is to utilize it for driving electric railways through the commercial distribution sphere. This proposition is interesting, both commercially and technically, and will be made the subject of a separate article. The employment of cheap gas power is destined to become a promoting factor of great weight in the electrification, also, of long-distance railways.

If one keeps in mind the facts that the application of gas power in the iron and coal industries from the blast furnace and coke oven, disregarding entirely the utilization of culm, will generate in the neighborhood of four and a half million horse-power the year around, and, in addition to what is consumed within the works will liberate an enormous amount of surplus energy which may be supplied to neighboring districts in form of heat or light or power, and that the actual saving thereby effected in the iron industry amounts under favorable conditions to one dollar per ton of pig produced and to three or four dollars per ton of finished goods turned out, then considerations of the character developed in this article will doubtless be given more attention than they would without referring to the extreme economic importance of the problem.

MUSHROOM CULTURE IN FRANCE.*

By Jacques Boyer.

The tourist who for the first time visits the southern and western plains of the suburbs of Paris is sure to be puzzled by certain quadrangular wooden towers which he perceives here and there rising out of the ground, and what still more excites his curiosity are the clouds of smoke that occasionally ascend from the strange structures, which are scattered over waste grounds, cultivated fields, and gardens. These structures, however, do not serve as housings for the secret prosecution of business of a criminal or questionable nature, but are simply shafts for the ventilation of old quarries that are at present used for the cultivation of those mushrooms that are so highly prized by the gourmets of the old and new worlds. The *Agaricus campestris*, called the field-mushroom, the only species that it is possible to domesticate, grows by preference on half-decomposed horse-manure. Dr. Repin says, "Its cradle was a melon-bed." But we do not know the name of the bright gardener who took some "spawn" from one of these beds in which mushrooms had grown spontaneously, and sowed it in new manure in order to obtain a second crop. There is good reason, however, for the belief that such culture originated in France in the latter half of the eighteenth century, and that at the outset the kitchen-gardeners who engaged in it in the spring and fall considered it as a natural adjunct to their business. Then, a century ago, a horticulturist named Chambray conceived the idea of devoting the abandoned subterranean quarries to the culture, since in them are found the conditions of temperature and humidity favorable to the development of the fungus. He succeeded thus in making a handsome profit, with the consequence that he had many imitators, who have tried to lease all the excavations abandoned by the quarrymen, so that the mushroom industry soon became one of the most prosperous of the environs of Paris.

At present, the suburban mushroom exploitations are almost exclusively distributed over the left bank of the Seine, in the section comprised between Meudon and Ivry. The most important are situated at Montrouge, Clamart, Vanves, Chatillon, Arcueil, and Sceaux, and formerly extended to the Quartier du Val-de-Grace in Paris.

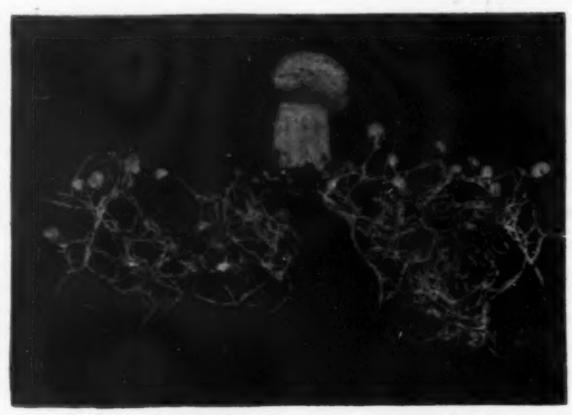
The galleries are excavated in limestone, as at Carriere-Saint-Denis; in gypsum, as at Argenteuil; or in white clay, as at Meudon; and the oldest of them (those from which the architects of the middle ages took the stone and plaster that enabled them to erect the public buildings of Paris) form a labyrinth of low and narrow chambers in which the workmen can scarcely move about without stooping.

VENTILATING SHAFT OF A MUSHROOM CAVE.

But the more modern exploitations, of which the accompanying engraving gives a faithful picture, consist of spacious galleries, of which the roof is supported by strong pillars carved out of the rock itself. Here the mushroom cultivator exercises his somber profession at his ease. The peg-ladder perceived in the interior of the ventilating-shaft will allow us to descend into the mysterious cave where here and there sparkle the oil or kerosene lamps that guide the cultivator.

Much preliminary work must be done to convert a quarry into a place for mushroom culture. After providing for the aeration of the galleries, a well must be dug from which to obtain the large quantity of water necessary, and after that a supply of horse-manure must be secured, this being the only material favorable to the development of the mushroom. Moreover, the quality of the manure plays a leading part in the yield. Preference is given to the manure of heavy Percherons or other draught horses which perform a great amount of muscular labor and are supplied with highly nitrogenized food.

After the material has been selected, the mushroom grower submits it to the following manipulations: It is first arranged in heaps about three feet high called "flows," whose bulk sometimes reaches 3,500 cubic feet, and should be at the least 750 feet. Then the whole is submitted to the action of the air for three weeks, and is turned over from time to time in order to diminish the intensity of the fermentation. In fact, according to Dr. Repin, manure acquires nutritive properties during the course of fermentation, for it is found that if fresh manure is sterilized and sowed with spores of mushrooms beginning to germinate, the fungus never accomplishes its complete evolution in such a medium. It germinates and sends out filaments, but does not fructify. The manure, in fermenting, becomes filled with microbes, which, according to the observations of various biologists, appear to be useful to mushroom culture only through the products elaborated. Their role is confined to favoring the chemical combustion by raising the temperature at the time of establishing the heaps or "flows." However this may be, at the end of a fortnight, the manure possesses a special odor somewhat recalling that of the field mushroom itself, and is ready to be lowered to the mushroom galleries. Here the workmen arrange it in beds as regular as possible in the center of the galleries, the rocky walls of which are supported here and there by piles of rubble to prevent them from falling in. In one of the illustrations workmen are seen in the act of forming rounded beds sixteen inches in width at the base and twenty inches in height, which they carefully align side by side along the galleries, like the furrows in a field. Such dimensions and such arrangement are not arbitrary, for experience has shown that under such conditions the manure becomes slightly heated anew and reaches a temperature of from 60 deg. F.

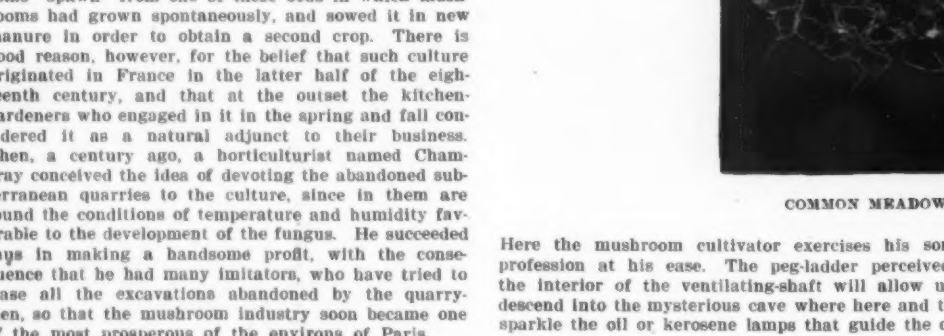


COMMON MEADOW MUSHROOM AND ITS SPAWN.

It is then time to begin the insertion of spawn into the beds. The vegetation of this mycelium, as botanists call it, which was suspended by dryness, always resumes its activity under the influence of humidity and heat. The fragments of spawn perform the function of slips. They throw out filaments which radiate in all directions and finally become disseminated through the bed in a length of time that varies according to the condition of the surrounding atmosphere. The copy of a photograph which was kindly sent to us by Prof. Atkinson, of the University of Ithaca, shows the ramifications of the mycelium along with the young mushrooms that have developed thereon.

The art of the mushroom grower afterward consists in rendering the local conditions propitious to the culture. The principal difficulty proceeds from the enormous quantity of oxygen which is absorbed by the respiration of the mushrooms, so that when the latter do not obtain a sufficient supply of air, they stop short in their growth. The galleries must, therefore, be strongly ventilated, the air therein be kept saturated with aqueous vapor, and variations of temperature be prevented, so delicate are the young fungi. Moreover, the mycelium, if left to itself, would not fructify well, and so the beds must undergo an operation which consists in covering the surface of the manure with a stratum of calcareous earth or sand and equalizing it with shovels. Finally, at the end of twenty-five or thirty days, during which the beds must be sprinkled, carefully inspected and freed from every bit of parasitic vegetation, the mushrooms begin to pierce the stratum that covers them. They do not, however, grow in a continuous manner. Crops separated by intervals of non-production succeed each other during three months, and the small, grayish white buttons are gathered by the grower whenever they become sufficiently rounded. With a basket under his arm, he walks along the beds and, delicately grasping the mushrooms with his fingers, quickly detaches them.

As for the varieties of mushrooms cultivated in the Parisian quarries, they differ in color, size, and weight. The three principal ones are the white, which are fine and in great demand, but do not withstand carriage very well; the light yellow, which are more



EARTHING THE MUSHROOM BEDS.

MUSHROOM CULTURE IN FRANCE.

* From American Homes and Gardens. Published by Munn & Co.

vigorous, more productive and less fragile; and the gray, which are fragrant, but acquire a dark color by age, which lowers their value in the market. Moreover, the fungi in a short time lose their character and undergo a degeneration. Consequently, growers rarely cultivate a given species for more than two or three years. They prefer to have recourse afterward to virgin spawn obtained by scientific processes that permit of selecting the mushrooms, or to reproduce the kinds deemed to be the best by direct germination of the spores.

The idea of preparing spawn through the germination of the spores occurred to various botanists a long time ago, but Messrs. Constantin and Matruchot alone succeeded a few years since in obtaining positive results. In order to obtain Agaricus spores, they placed a mature mushroom on a sheet of paper and then collected them a few days afterward in the form of an impalpable brown powder. In order to cause them to germinate, they had recourse to the media used in bacteriology—moist air, damp sand, or dung, for example. The spores ready for germination become distended in the first place in taking on a light color, and then throw out from one of their poles a very fine tube which enlarges and ramifies in all directions in budding. In this way there is formed a small tuft of mycelium, which, in a favorable medium—manure, for example—will extend indefinitely.

Dr. Repin applies this process industrially in the following manner: After distributing the manure in strata of equal thickness between superposed steel plates, he submits the whole to a pressure of seven hundred pounds to the square inch. On coming from the press the whole is found to be agglomerated into a plate about one-half an inch in thickness and almost as hard as wood. He then sows these plates with spores and places them under conditions most favorable for the development of the mycelium, but in such a way as to protect them from elevations of temperature to as great a degree as possible. The vegetation of the spawn is retarded, although its vigor increases when it is introduced into the warmish atmosphere of the mushroom gallery.

After the plates of manure have become entirely permeated by the mycelium, they are cut by a machine into pieces four inches square, each of which represents an insertion. The mushroom grower can therefore lay in a supply of the variety that is best adapted to his quarry, for this virgin spawn remains free from the diseases which attack mushrooms, and particularly that which is called "softening," so dreaded by Parisian growers, whom it annually costs more than a million francs. The mushrooms attacked by the cryptogam that causes the disease become atrophied and covered with a rosy down, and, at the epoch of their maturity, become deliquescent.

We shall finish by giving a few statistics designed to show the importance of this Parisian industry. There exist at present in the department of the Seine about two hundred and fifty mushroom installations owned by eighty individuals, not counting a score of other exploitations distributed through the neighboring departments. The number of workmen employed in the industry exceeds a thousand. The total value of the mushrooms annually produced in the suburbs of Paris amounts to twelve million francs, and certain tradesmen of the Halles make an exclusive specialty of their sale. Naturally the industry thereof ranks as a most important one in Paris.

SPRINKLING THE MUSHROOM BEDS.

THE ENTRANCE TO A PARISIAN MUSHROOM CAVE.

FORMING THE BEDS OF MANURE.

MUSHROOM CULTURE IN FRANCE.

THE DISEASES OF BREAD.*

Just as the living organisms of man, animals, and plants suffer various changes as the result of disease, so also many of our manufactured products are subject to undesirable changes in their character. Among our most dangerous foes in this respect are those minute living beings, known as micro-organisms, that are endowed with the power to resolve dead organic substances into simpler compounds, as, for example, in the decay of animal and vegetable materials. When such parasites invade the living organism, we speak of this condition as a disease. Bread contains all the essential nutrients for the human organism, including proteids, carbohydrates, fat, mineral salts, and water; it goes without saying, therefore, that it also supplies abundant food for the less discriminating lower organisms, such as the bacteria. In not a few instances, indeed, the bacteriologist resorts to bread as a culture medium for bacteria. To a great extent, however, bread is protected against these tiny foes by the hard crust in which it is incased as a result of the action of the high temperature in the baker's oven on the wet surface of the loaves. But while this crust effectively protects bread as long as it is fresh, this is not the case when bread is kept for some time in a damp place. The spores of micro-organisms are constantly floating in the air, and while the heat of baking probably destroys the great majority of those present in the crumb, new ones will find their way to the crust of the loaves. If this crust has become soft by exposure to damp air, then the micro-organisms that have lodged upon it begin to sprout and the threads will thrust themselves into the soft crumb within, producing what may be called diseases of the bread. In some instances such infected bread has been known to produce symptoms of poisoning; the crumb then probably contained some alkaloidal body chemically resembling strychnine.

Among the diseases of bread we may also include such changes in its appearance or character as will render it unfit for sale or consumption. They may be the result either of a lack of care in preparing the dough, or of employing inferior or unsound materials, such as adulterated flour or a poor quality of yeast.

We shall now proceed to consider the diseases of bread from the points of view just indicated, viz., (1) the diseases due to unsound materials; (2) diseases resulting from lack of care on the part of the baker; and (3) diseases due to bacterial infection.

1. DISEASES DUE TO THE USE OF UNSOUND MATERIALS.

By reason of its composition, as well as of its very fine state of division, flour is subject to many undesirable changes. Bacterial growths impart to it a musty odor and taste, while the decomposition of its fat contents may turn it rancid. In both cases the taste may suffer without any chemically determinable quantities of the constituents having been affected; nevertheless, the objectionable taste adheres even to the finished product. Flour should not be stored in damp and ill-ventilated places. Not only is it threatened by a flora of bacteria, molds, and yeasts, but also by a fauna of injurious insects, such as flour mites, meal worms, weevils, etc. Different varieties of flour, too, show very different keeping qualities on storage. Thus rye flour is exceedingly sensitive to various influences, while wheat flour may be preserved for a considerable length of time.

Not infrequently flour is damaged in the flouring mill. The heat produced in grinding may scorch the flour; or, if the grain is damp, the combined action of heat and moisture may cause gelatinization by the conversion of starch into dextrin.

Grain harvested in rainy weather has a tendency to sprout, and flour obtained from it yields bread whose crust shows many cracks and crevices.

The flour used for bread-making sometimes contains seeds of poisonous weeds, like the darnel (*Lolium tremulentum*) and ergot of rye (*Secale cornutum*). Other seeds, such as those of Rhinanthus and Melampyrum, communicate to the bread made from flour that contains them yellowish, bluish, or reddish colorations. The machines now employed for cleaning grain are so perfect that an admixture of such foreign seeds in it is hardly to be expected. Indeed, Stohmann pronounces the contamination of flour with such seeds as criminal.

To a great extent, also, the character of a flour and of the bread made from it depend on the nature of the grain. Thus buckwheat, barley, English wheat, and corn are not well adapted for break-making purposes, while rye and wheat yield the best results.

Another possible source of infection in bread is the yeast employed for leavening the crumb. The kind of yeast used for wheat bread is the compressed yeast manufactured in large and generally well-conducted plants; but even this product may be infected with bacteria which impart an unpleasant flavor to the bread made with its aid. High-grade compressed yeast should be made from pure-culture yeasts; it should be

* Pure Products.

third is to be coked. With this amount at least 17,000 horse-power is generated in gas engines, while only 10,000 is used in the collieries. The surplus energy is sent in form of electric current at 10,000 to 20,000 volts, to the city of Krefeld and its new Rhein harbor, where it is transformed and sold at 1.9 and 1.7 cents per kilowatt-hour respectively.

Another and very promising way of disposing of the surplus energy is to utilize it for driving electric railways through the commercial distribution sphere. This proposition is interesting, both commercially and technically, and will be made the subject of a separate article. The employment of cheap gas power is destined to become a promoting factor of great weight in the electrification, also, of long-distance railways.

If one keeps in mind the facts that the application of gas power in the iron and coal industries from the blast furnace and coke oven, disregarding entirely the utilization of culm, will generate in the neighborhood of four and a half million horse-power the year around, and, in addition to what is consumed within the works will liberate an enormous amount of surplus energy which may be supplied to neighboring districts in form of heat or light or power, and that the actual saving thereby effected in the iron industry amounts under favorable conditions to one dollar per ton of pig produced and to three or four dollars per ton of finished goods turned out, then considerations of the character developed in this article will doubtless be given more attention than they would without referring to the extreme economic importance of the problem.

MUSHROOM CULTURE IN FRANCE.*

By JACQUES BOYER.

THE tourist who for the first time visits the southern and western plains of the suburbs of Paris is sure to be puzzled by certain quadrangular wooden towers which he perceives here and there rising out of the ground, and what still more excites his curiosity are the clouds of smoke that occasionally ascend from the strange structures, which are scattered over waste grounds, cultivated fields, and gardens. These structures, however, do not serve as housings for the secret prosecution of business of a criminal or questionable nature, but are simply shafts for the ventilation of old quarries that are at present used for the cultivation of those mushrooms that are so highly prized by the gourmets of the old and new worlds. The *Agaricus campestris*, called the field-mushroom, the only species that it is possible to domesticate, grows by preference on half-decomposed horse-manure. Dr. Repin says, "Its cradle was a melon-bed." But we do not know the name of the bright gardener who took some "spawn" from one of these beds in which mushrooms had grown spontaneously, and sowed it in new manure in order to obtain a second crop. There is good reason, however, for the belief that such culture originated in France in the latter half of the eighteenth century, and that at the outset the kitchen-gardeners who engaged in it in the spring and fall considered it as a natural adjunct to their business. Then, a century ago, a horticulturist named Chambray conceived the idea of devoting the abandoned subterranean quarries to the culture, since in them are found the conditions of temperature and humidity favorable to the development of the fungus. He succeeded thus in making a handsome profit, with the consequence that he had many imitators, who have tried to lease all the excavations abandoned by the quarrymen, so that the mushroom industry soon became one of the most prosperous of the environs of Paris.

At present, the suburban mushroom exploitations are almost exclusively distributed over the left bank of the Seine, in the section comprised between Meudon and Ivry. The most important are situated at Montrouge, Clamart, Vanves, Chatillon, Arcueil, and Sceaux, and formerly extended to the Quartier du Val-de-Grace in Paris.

The galleries are excavated in limestone, as at Carriere-Saint-Denis; in gypsum, as at Argenteuil; or in

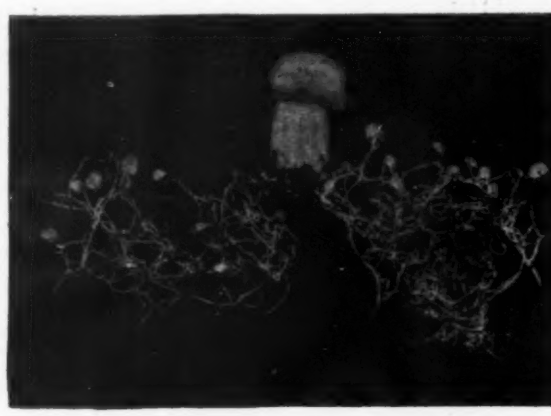
VENTILATING SHAFT OF A MUSHROOM CAVE.

white clay, as at Meudon; and the oldest of them (those from which the architects of the middle ages took the stone and plaster that enabled them to erect the public buildings of Paris) form a labyrinth of low and narrow chambers in which the workmen can scarcely move about without stooping.

But the more modern exploitations, of which the accompanying engraving gives a faithful picture, consist of spacious galleries, of which the roof is supported by strong pillars carved out of the rock itself. Here the mushroom cultivator exercises his somber profession at his ease. The peg-ladder perceived in the interior of the ventilating-shaft will allow us to descend into the mysterious cave where here and there sparkle the oil or kerosene lamps that guide the cultivator.

Much preliminary work must be done to convert a quarry into a place for mushroom culture. After providing for the aeration of the galleries, a well must be dug from which to obtain the large quantity of water necessary, and after that a supply of horse-manure must be secured, this being the only material favorable to the development of the mushroom. Moreover, the quality of the manure plays a leading part in the yield. Preference is given to the manure of heavy Percherons or other draught horses which perform a great amount of muscular labor and are supplied with highly nitrogenized food.

After the material has been selected, the mushroom grower submits it to the following manipulations: It is first arranged in heaps about three feet high called "flows," whose bulk sometimes reaches 3,500 cubic feet, and should be at the least 750 feet. Then the whole is submitted to the action of the air for three weeks, and is turned over from time to time in order to diminish the intensity of the fermentation. In fact, according to Dr. Repin, manure acquires nutritive properties during the course of fermentation, for it is found that if fresh manure is sterilized and sowed with spores of mushrooms beginning to germinate, the fungus never accomplishes its complete evolution in such a medium. It germinates and sends out filaments, but does not fructify. The manure, in fermenting, becomes filled with microbes, which, according to the observations of various biologists, appear to be useful to mushroom culture only through the products elaborated. Their role is confined to favoring the chemical combustion by raising the temperature at the time of establishing the heaps or "flows." However this may be, at the end of a fortnight, the manure possesses a special odor somewhat recalling that of the field mushroom itself, and is ready to be lowered to the mushroom galleries. Here the workmen arrange it in beds as regular as possible in the center of the galleries, the rocky walls of which are supported here and there by piles of rubble to prevent them from falling in. In one of the illustrations workmen are seen in the act of forming rounded beds sixteen inches in width at the base and twenty inches in height, which they carefully align side by side along the galleries, like the furrows in a field. Such dimensions and such arrangement are not arbitrary, for experience has shown that under such conditions the manure becomes



COMMON MEADOW MUSHROOM AND ITS SPAWN.

slightly heated anew and reaches a temperature of from 60 deg. F.

It is then time to begin the insertion of spawn into the beds. The vegetation of this mycelium, as botanists call it, which was suspended by dryness, always resumes its activity under the influence of humidity and heat. The fragments of spawn perform the function of slips. They throw out filaments which radiate in all directions and finally become disseminated through the bed in a length of time that varies according to the condition of the surrounding atmosphere. The copy of a photograph which was kindly sent to us by Prof. Atkinson, of the University of Ithaca, shows the ramifications of the mycelium along with the young mushrooms that have developed thereon.

The art of the mushroom grower afterward consists in rendering the local conditions propitious to the culture. The principal difficulty proceeds from the enormous quantity of oxygen which is absorbed by the respiration of the mushrooms, so that when the latter do not obtain a sufficient supply of air, they stop short in their growth. The galleries must, therefore, be strongly ventilated, the air therein be kept saturated with aqueous vapor, and variations of temperature be prevented, so delicate are the young fungi. Moreover, the mycelium, if left to itself, would not fructify well, and so the beds must undergo an operation which consists in covering the surface of the manure with a stratum of calcareous earth or sand and equalizing it with shovels. Finally, at the end of twenty-five or thirty days, during which the beds must be sprinkled, carefully inspected and freed from every bit of parasitic vegetation, the mushrooms begin to pierce the stratum that covers them. They do not, however, grow in a continuous manner. Crops separated by intervals of non-production succeed each other during three months, and the small, grayish white buttons are gathered by the grower whenever they become sufficiently rounded. With a basket under his arm, he walks along the beds and, delicately grasping the mushrooms with his fingers, quickly detaches them.

As for the varieties of mushrooms cultivated in the Parisian quarries, they differ in color, size, and weight. The three principal ones are the white, which are fine and in great demand, but do not withstand carriage very well; the light yellow, which are more

* From American Homes and Gardens. Published by Munn & Co.

EARTHING THE MUSHROOM BEDS.

MUSHROOM CULTURE IN FRANCE.

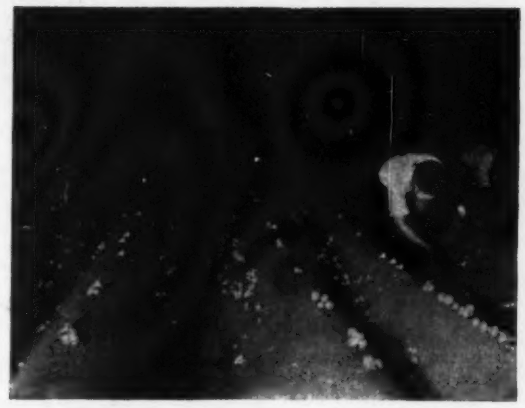
vigorous, more productive and less fragile; and the gray, which are fragrant, but acquire a dark color by age, which lowers their value in the market. Moreover, the fungi in a short time lose their character and undergo a degeneration. Consequently, growers rarely cultivate a given species for more than two or three years. They prefer to have recourse afterward to virgin spawn obtained by scientific processes that permit of selecting the mushrooms, or to reproduce the kinds deemed to be the best by direct germination of the spores.

The idea of preparing spawn through the germination of the spores occurred to various botanists a long time ago, but Messrs. Constantin and Matruchot alone succeeded a few years since in obtaining positive results. In order to obtain Agaricus spores, they placed a mature mushroom on a sheet of paper and then collected them a few days afterward in the form of an impalpable brown powder. In order to cause them to germinate, they had recourse to the media used in bacteriology—moist air, damp sand, or dung, for example. The spores ready for germination become distended in the first place in taking on a light color, and then throw out from one of their poles a very fine tube which enlarges and ramifies in all directions in budding. In this way there is formed a small tuft of mycelium, which, in a favorable medium—manure, for example—will extend indefinitely.

Dr. Repin applies this process industrially in the following manner: After distributing the manure in strata of equal thickness between superposed steel plates, he submits the whole to a pressure of seven hundred pounds to the square inch. On coming from the press the whole is found to be agglomerated into a plate about one-half an inch in thickness and almost as hard as wood. He then sows these plates with spores and places them under conditions most favorable for the development of the mycelium, but in such a way as to protect them from elevations of temperature to as great a degree as possible. The vegetation of the spawn is retarded, although its vigor increases when it is introduced into the warmish atmosphere of the mushroom gallery.

After the plates of manure have become entirely permeated by the mycelium, they are cut by a machine into pieces four inches square, each of which represents an insertion. The mushroom grower can therefore lay in a supply of the variety that is best adapted to his quarry, for this virgin spawn remains free from the diseases which attack mushrooms, and particularly that which is called "softening," so dreaded by Parisian growers, whom it annually costs more than a million francs. The mushrooms attacked by the cryptogam that causes the disease become atrophied and covered with a rosy down, and, at the epoch of their maturity, become deliquescent.

We shall finish by giving a few statistics designed to show the importance of this Parisian industry. There exist at present in the department of the Seine about two hundred and fifty mushroom installations owned by eighty individuals, not counting a score of other exploitations distributed through the neighboring departments. The number of workmen employed in the industry exceeds a thousand. The total value of the mushrooms annually produced in the suburbs of Paris amounts to twelve million francs, and certain tradesmen of the Halles make an exclusive specialty of their sale. Naturally the industry thereof ranks as a most important one in Paris.



SPRINKLING THE MUSHROOM BEDS.

THE ENTRANCE TO A PARISIAN MUSHROOM CAVE.

FORMING THE BEDS OF MANURE.

MUSHROOM CULTURE IN FRANCE.

THE DISEASES OF BREAD.*

JUST as the living organisms of man, animals, and plants suffer various changes as the result of disease, so also many of our manufactured products are subject to undesirable changes in their character. Among our most dangerous foes in this respect are those minute living beings, known as micro-organisms, that are endowed with the power to resolve dead organic substances into simpler compounds, as, for example, in the decay of animal and vegetable materials. When such parasites invade the living organism, we speak of this condition as a disease. Bread contains all the essential nutrients for the human organism, including proteids, carbohydrates, fat, mineral salts, and water; it goes without saying, therefore, that it also supplies abundant food for the less discriminating lower organisms, such as the bacteria. In not a few instances, indeed, the bacteriologist resorts to bread as a culture medium for bacteria. To a great extent, however, bread is protected against these tiny foes by the hard crust in which it is incased as a result of the action of the high temperature in the baker's oven on the wet surface of the loaves. But while this crust effectively protects bread as long as it is fresh, this is not the case when bread is kept for some time in a damp place. The spores of micro-organisms are constantly floating in the air, and while the heat of baking probably destroys the great majority of those present in the crumb, new ones will find their way to the crust of the loaves. If this crust has become soft by exposure to damp air, then the micro-organisms that have lodged upon it begin to sprout and the threads will thrust themselves into the soft crumb within, producing what may be called diseases of the bread. In some instances such infected bread has been known to produce symptoms of poisoning; the crumb then probably contained some alkaloidal body chemically resembling strychnine.

Among the diseases of bread we may also include such changes in its appearance or character as will render it unfit for sale or consumption. They may be the result either of a lack of care in preparing the dough, or of employing inferior or unsound materials, such as adulterated flour or a poor quality of yeast.

We shall now proceed to consider the diseases of bread from the points of view just indicated, viz., (1) the diseases due to unsound materials; (2) diseases resulting from lack of care on the part of the baker; and (3) diseases due to bacterial infection.

1. DISEASES DUE TO THE USE OF UNSOUND MATERIALS.

By reason of its composition, as well as of its very fine state of division, flour is subject to many undesirable changes. Bacterial growths impart to it a musty odor and taste, while the decomposition of its fat contents may turn it rancid. In both cases the taste may suffer without any chemically determinable quantities of the constituents having been affected; nevertheless, the objectionable taste adheres even to the finished product. Flour should not be stored in damp and ill-ventilated places. Not only is it threatened by a flora of bacteria, molds, and yeasts, but also by a fauna of injurious insects, such as flour mites, meal worms, weevils, etc. Different varieties of flour, too, show very different keeping qualities on storage. Thus rye flour is exceedingly sensitive to various influences, while wheat flour may be preserved for a considerable length of time.

Not infrequently flour is damaged in the flouring mill. The heat produced in grinding may scorch the flour; or, if the grain is damp, the combined action of heat and moisture may cause gelatinization by the conversion of starch into dextrin.

Grain harvested in rainy weather has a tendency to sprout, and flour obtained from it yields bread whose crust shows many cracks and crevices.

The flour used for bread-making sometimes contains seeds of poisonous weeds, like the darnel (*Lolium tremulentum*) and ergot of rye (*Secale cornutum*). Other seeds, such as those of Rhinanthus and Melampyrum, communicate to the bread made from flour that contains them yellowish, bluish, or reddish colorations. The machines now employed for cleaning grain are so perfect that an admixture of such foreign seeds in it is hardly to be expected. Indeed, Stohmann pronounces the contamination of flour with such seeds as criminal.

To a great extent, also, the character of a flour and of the bread made from it depend on the nature of the grain. Thus buckwheat, barley, English wheat, and corn are not well adapted for break-making purposes, while rye and wheat yield the best results.

Another possible source of infection in bread is the yeast employed for leavening the crumb. The kind of yeast used for wheat bread is the compressed yeast manufactured in large and generally well-conducted plants; but even this product may be infected with bacteria which impart an unpleasant flavor to the bread made with its aid. High-grade compressed yeast should be made from pure-culture yeasts; it should be

* Pure Products.

free from other races of yeast and be of the top-fermenting type. It is not uncommon, however, that compressed yeasts contain different varieties of yeast, or are contaminated with the bacteria of vinegar and of lactic and butyric acid fermentation. Compressed yeast is either specially manufactured for the bakers' trade, or else, particularly in Germany, it is a by-product of the breweries producing top-fermented beers. Brewer's yeast, as a rule, has a bitter taste derived from the hops, and it is absolutely necessary that this taste be removed before the yeast becomes fit for bread-making; resins of the hops are readily soluble in alkalies, but unfortunately, the vigor and fermenting power of yeast is greatly impaired by these chemicals, soda being the least injurious of them. The bottom-fermentation yeasts, which now constitute a waste product of so many breweries, are not available for bread-making, owing to their inferior and somewhat irregular fermenting power. In Germany the use of such yeasts in bakeries is legally prohibited.

While the dough made from wheat flour is fermented with yeast, it is customary to raise that from rye flour with leaven (Sauerteig). This contains, in addition to the yeast-fungi considerable quantities of lactic acid bacteria. The acid produced by them imparts a somewhat sour taste to the product and at the same time serves to improve the keeping qualities of the dough. It is well known that it is the custom in distilleries to induce a lactic fermentation (sour mash) before the alcoholic fermentation is proceeded with: in the same way the growth of foreign bacteria is suppressed in bread-making by the use of an acid fermenting dough. A piece of the dough is daily put aside, so that an unlimited number of generations result from it. In this way, however, various bacteria may enter the dough, and while at first their presence may not be noticed, they may develop to an alarming extent when the conditions are favorable to their growth. For this reason attempts have been made to produce pure cultures of lactic bacteria to be mixed with pure distillery yeast in the manufacture of pressed yeasts, so that these might take the place of leaven. The rye bread manufactured in larger towns and cities is without a pronounced sour taste; it is made with the aid of leaven which is daily renewed, so that the lactic bacteria have no chance to develop at the expense of the yeasts. It is different with the black bread of rural localities. It may happen that a piece of leaven is allowed to lie for days and even weeks before it is used. Such old leaven is apt to run into the acid fermentation alone, the lactic and butyric bacteria preponderating over the yeast.

Another peculiarity of leaven is to impart to the bread a rather dark color owing to the action of an enzyme, cerealin, upon the gluten. Special precautions must be observed to prevent this in the preparation of fine wheat bread. A suitable method of bread-making has been devised by Mège-Mouriès, and a description of it may be found in this magazine 1906, p. 18.

2. DISEASES OF BREAD DUE TO FAULTY MANIPULATION.

Trouble may result from careless handling at any stage of the bread-making process. We shall merely refer, however, to such defects as are caused unintentionally or through ignorance. Where wood is used as fuel it may occur that old lumber from torn-down buildings, or discarded railroad ties are employed for this purpose. If such wood is coated with lead paint or treated with zinc salts, metallic oxides will collect on the walls of the ovens and thence find their way into the bread, rendering the latter poisonous.

In preparing the dough, trouble may be caused by an imperfect mixing of the ingredients. If the dough is made too thin, it allows the escape of carbonic acid that is required to raise the bread. While the raising at first proceeds rapidly, the mass soon collapses and yields bread which is poor in texture and indigestible.

Kneading machines are preferable to manual labor, being not only more convenient but also more effective.

Other defects due to faulty handling at the different stages of bread-making are streakiness, lack of adhesion of the crumb to the crust, excess of moisture, imperfect porosity, too dense a texture, and excessive acidity. If the dough is allowed to ferment too long or at too high a temperature, the bread will be overfermented and show large cavities in its crumb, defects which may be readily avoided by suitable precautions.

Let us now consider the diseases of bread which are not caused by imperfect materials or faulty manipulation.

3. DISEASES DUE TO BACTERIA.

We are all familiar with the appearance of moldy bread. This condition is brought about by the growth of a mold fungus (*Pencillium glaucum*). This fungus may assume different colors, such as olive green, lemon, brown, or red. These molds produce certain chemical changes in the bread; thus, the ordinary blue mold gives rise to the formation of alcohol and nitric acid, the loss in substance amounting to as much as 18 per cent of the bread. The molds feed principally upon starch and other carbohydrates, and for this reason the composition of the bread then shows a decrease in the percentage of such constituents, while those of fat and crude fiber are correspondingly increased. The fluffy white growth is the mold called *Mucor mucedo*, and an orange-colored coating of mold is due to *Oidium aurantiacum*. Another mold, named *Rhicopos nigricans*, is nearly black. All these fungi render bread unappetizing and unpalatable, and, with the exception of the blue mold, impart to the bread a somewhat poisonous character.

It is recorded that 0.5 gramme of the blue mold taken upon an empty stomach produced no ill effects.

The fungus called *Monas prodigiosa* produces a red pigment; it is of interest since it has given rise to the traditions of the bleeding host and the bleeding bread.

The most serious of the diseases of bread is that known as sliminess or ropiness. It is caused by the growth of bacteria that transform starch into dextrins and sugars, and of proteids into ammonia and soluble peptones. Fats, pentosans, and crude fiber are not affected by it. The slimy matter in such infected bread is not a product of changes in its composition, but is made up of the membranes of the bacteria.

SOLDERS.*

HARD SOLDERS.

IN treating of soft solders, in the last article on this subject, it was shown that the fusing point of these compositions varies considerably. The variations are still greater in the case of hard solders, whose composition is such that they melt only on being brought to strong red heat. Some of them can be melted in the ordinary way, with the aid of a soldering iron, while in the case of others, a special apparatus, such as a bellows, must be employed, or the whole object to be soldered must be strongly heated. The numerous kinds of hard solders, with different fusing points, are made necessary by the difference in the nature of the various metals and metallic compositions which may require soldering.

Copper Solders.—Although many hard solders contain copper, and might therefore be classed with copper solders, we will here consider under that name only those whose essential constituent is copper. Copper is a metal which melts only at very high temperatures, and affects in this way its alloys with other metals; any solders containing copper are hence always to be called hard. But the fusing point is generally lowered as the amount of copper is decreased.

Pure copper, on account of its strength and tenacity, is an excellent material for soldering, and is much used for cast iron, wrought iron, and steel. Where its color is no objection, it is to be highly recommended for use with the above-mentioned metals. It may be employed in the form of thin strips, or in filings scattered over the place to be soldered, this according to the nature of the surface.

Fine copper filings are sometimes used to solder copper itself, and with the best results; but usually alloys containing a large percentage of copper, but more easily fusible than copper itself, are used.

These (used also for bronze) are mixtures of copper and lead. The more lead they contain the more readily fusible they become, of course, and the less they resemble copper in color or in point of tenacity. The most common copper solder is composed of 5 parts of copper to 1 of lead. Another has copper 80 parts, lead 15, and tin 5.

Copper amalgam, that is, a compound of copper and mercury, is very well adapted to soldering such copper and bronze articles as cannot be exposed to strong heat. This is prepared by first precipitating the copper from a solution of blue vitriol, which is done by putting in sheets of zinc and shaking. The copper will be in the form of a very fine powder. From 20 to 36 parts by weight of this powder, according as the solder is to be harder or softer, are put into a porcelain mortar, and enough sulphuric acid is poured on to make a paste, then 70 parts of mercury are stirred in. After a uniform mass has been obtained, the sulphuric acid is washed out, and the amalgam will be left, after ten or twelve hours, as a hard mass, capable of being polished. If heated to 662 deg. F. it becomes soft and malleable.

In soldering, the seams of the copper or bronze articles are brushed over with a solution of mercury, the so-called amalgamating fluid, and become white from the separation of mercury. The amalgam, powdered, is scattered over, and by passing the hot soldering iron over the places, the soldering is completed. The amalgamating fluid is made by dissolving 10 parts by weight of mercury in 11 parts of nitric acid, and diluting the solution with 500 to 550 parts of soft water.

Brass Solder.—This is a very important kind of solder, used by many metal workers to solder brass, bronze, copper, iron, and steel. From its composition it may be considered a kind of brass, to which are sometimes added small quantities of tin.

Brass, as we know, is an alloy of copper and zinc. Most kinds of brass have an average composition of 68 to 70 per cent of copper to 32 to 30 per cent of zinc; but there are certain special varieties in which varying quantities of zinc, from 24 to 40 per cent, may be found.

The less zinc there is in brass, the more it approaches copper in its general characteristics; increasing quantities of zinc tend to make it brittle and crystalline. As a rule, alloys for hard solders should not contain more than 34 per cent of zinc.

The fusing point of brass is raised as the amount of copper is increased; an alloy containing 90 per cent of copper melts at 1,060 deg. C. (1,940 deg. F.), with 80 per cent of copper the fusing point is 1,020 deg. C. (1,868 deg. F.), with 50 per cent 980 deg. C. (1,796 deg. F.), with 50 per cent 950 deg. C. (1,742 deg. F.).

As the alloy becomes more readily fusible with an increase of zinc, the color also changes essentially, and the alloy becomes much more brittle. The latter property may be modified by using partly zinc and partly tin, thus giving the alloy a resemblance to bronze. The durability of the solder is not affected, but it is made much less brittle and more readily fusible. If, however, more than a certain percentage of tin is added, the solder becomes thin and somewhat soft, gray-white in color, and very brittle again, so much so that the seams will separate if the article is bent. For this reason great care must be exercised in making the mixtures of zinc and tin.

If metals are to be soldered which are very difficult of fusion, brass itself may be used directly as a solder; a very hard solder may be made by melting brass and mixing in copper. There are numerous formulas for hard solders, but not all of them are reliable; a few will be given here, all of which have been well tested and found excellent. The hardest are given first.

Yellow Hard Solders.

(Very Hard.)

Appelbaum's Compositions.

I.

Copper	58
Zinc	42

II.

Sheet brass	85.42
Zinc	13.58

Karmarsch's Composition.

III.

Brass	7
Zinc	1

Prechtl's Composition.

IV.

Copper	53.30
Zinc	43.10
Tin	1.30
Lead	0.30

The foregoing compositions have the yellow color of brass, are very strong, and require very high temperatures for melting, so that they can be used for copper, bronze, steel, and all kinds of iron. The ones next given melt more easily than the first, and are suitable for all kinds of work with brass.

I.

Sheet brass	81.12
Zinc	18.88

II.

Copper	54.08
Zinc	45.29

III.

Brass	3 to 4
Zinc	1

IV.

Brass	78.26
Zinc	17.41
Silver	4.33

IV. is somewhat expensive on account of the silver, but has the valuable property of being at once tenacious and ductile, and can be worked into wire with hammer or rollers.

Still softer are:

I.

Brass	5
Zinc	2.5

II.

Brass	5
Zinc	5

Half-White.

I.

Copper	53.3
Zinc	46.7

II.

Brass	12
Zinc	4 to 7
Tin	1

III.

Brass	22
Zinc	10
Tin	1

IV.

Copper	44
Zinc	49
Tin	3.20
Lead	1.20

I. (Volk's hard solder) and IV. (Prechtl's half-white) are quite readily fusible.

White.

I.

Brass	20
Zinc	1
Tin	4

II.

Brass	11
Zinc	1
Tin	2

III.

Brass	6
Zinc	4
Tin	10

IV.

Copper	57.44
Zinc	27.98
Tin	14.58

A. Krupp, in his excellent work, gives the following table of the compositions of hard solders, all of which have been verified in practice. The proportions are given in percentage. The terms "hard" and "soft" refer, of course, to the respective degrees of fusibility, being simply comparative, as the whole class of solders which we are now considering are called in general "hard."

A. Solders Prepared from the Pure Metals.

	Copper.	Zinc.	Tin.	Lead.
Very hard	57.94	42.06	....	....
Very hard	58.33	41.67	....	....
Hard	50.00	50.00	....	....
Soft	33.34	66.66	....	....
Soft (half-white)	44.00	49.90	3.30	1.20
Soft (white)	57.44	27.98	14.58	....
Soft	72.00	18.00	4.00	....
Soft (Volk's)	53.30	46.70	....	....

* The first installment appeared in SUPPLEMENT No. 1610.

B. Solders of Brass and Zinc.

	Brass.	Zinc.	Tin.
Very hard	85.42	12.58	....
Very hard	7.00	1.00	....
Hard	3.00	1.00	....
Hard	4.00	1.00	....
Soft	5.00	2.00	....
Soft	5.00	4.00	....
Half-white	12.00	5.00	1.00
Half-white	44.00	20.00	2.00
White	40.00	2.00	8.00
White	22.00	2.00	4.00
White	18.00	12.00	30.00
Very ductile	78.25	17.25	....
For brazier's work	81.12	18.88	....

C. Brass Solders.

	Copper.	Zinc.	Tin.	Lead.
Yellow, hard	53.30	43.10	1.30	0.30
Half-white, soft	44.00	49.90	3.30	1.20
White	57.44	27.98	14.58	....

German Silver Solders.

The solders thus classified, as their name implies, are used principally for soldering German silver. This alloy contains nickel, and is very hard and white and it requires solders which have corresponding qualities. German silver belongs among the alloys which are very difficult of fusion, and the solders used for it are those which have very high fusing points, and belong therefore to the general class of hard solders. They have great strength, and are used for other purposes, in cases where the object to be soldered is exposed to heavy strain. German silver solder can be given a color very much like that of steel, and is much used in steel work.

In regard to its composition, it bears this relation to ordinary hard solders, that while these may be considered to be brass with an admixture of zinc, German silver solder may be called a mixture of zinc and German silver. It is softer or harder according to the greater or less amount of zinc contained in it; but if this exceeds a certain limit, the solder becomes very brittle.

There are two principal varieties of German silver solder, called, relatively, hard and soft. The former is exceedingly strong, on account of the large amount of nickel it contains, and is sometimes called "steel solder," being quite generally used for soldering steel.

Soft German Silver Solders.

I.

Copper	4.5
Zinc	7.0
Nickel	1.0

II.

Copper	35.0
Zinc	56.5
Nickel	8.5

III.

German silver	5
Zinc	4

I. and II. are quite similar in composition, and have correspondingly similar properties; in III., German silver, that is, a compound of copper, zinc, and nickel, is used directly, and in preparing this solder it is necessary to know the exact composition of the alloy, or to try the solder in small quantities, in order to judge of the correct amount of zinc to be added. It may be assumed that the proportions are correct, when the metallic mixture is lustrous, and brittle enough to allow of pulverizing when hot, and when it will become fluid in contact with a red hot soldering iron.

Hard German Silver Solders (Steel Solders).

I.

Copper	35
Zinc	56.5
Nickel	9.5

II.

Copper	38
Zinc	50
Nickel	12

I. requires a very hot flame for melting, and II. can usually be melted only by applying bellows to the flame.

In preparing German silver solder by direct melting together of the three metals, the copper is first to be melted, then the zinc and nickel added simultaneously. It can also be made by melting German silver together with zinc, a method which is not only more convenient, but has other advantages, especially if the solder is needed only in small quantities. The temperature required for melting this solder is so high that some of the zinc, which is very volatile, will evaporate if used pure, and it is difficult to obtain a mixture containing the proper amount of zinc.

The German silver is first melted, and heated very hot, and about six-tenths of the quantity of zinc is then thrown in. The melted mass is immediately stirred with an iron rod and a sample of it is taken out, by means of an iron spoon with a beak, and poured upon a cold stone or iron plate. As soon as it has stiffened, it is put into a mortar to be pulverized. If a few vigorous strokes will accomplish this, the alloy is of the right composition; but if it cannot be pulverized, there is too little zinc. If, on the other hand, the alloy is so brittle, while still hot, that a blow of a hammer will break it to pieces, and if it is very easily powdered in the mortar, an excess of zinc is indicated, and it will not only be too soft, but lose in strength. Too much zinc is also shown by a very high luster.

More zinc can be added as required, and if there is already too much, this can be remedied in either of two ways; either the alloy is kept a long time in fusion, so that a certain quantity of zinc evaporates, or more German silver is added. This method is preferable, as it saves consumption of fuel, and no zinc is lost. The German silver should be added in the form of filings, as it is obtained from the manufactories of German silver articles, in order to insure quick and thorough mixture. The filings are to be scattered over the alloy, and stirred in with a hardwood stick. When this is dipped into the melted mass, the wood begins to decompose, on account of the great heat, and gases are developed which have a reducing effect, and cause an intimate mixture of the constituents.

In soldering German silver articles, which are not to be exposed to very high temperatures, the soft German silver solders are generally used, and the correct composition is hardly to be distinguished from the German silver itself, since the color is nearly the same. The solder is employed in the form of a fine powder, which has the advantage that it can be applied quickly and no more used than necessary.

It is best to heat the mortar, in which the solder is pulverized, very hot, and to pour out the melted solder upon a large iron plate, in a thin layer, which is at once broken in pieces with a hammer and thrown into the mortar. The powder, which will be in grains of uneven size, is put through a hair sieve, and the fine portions used for solder, the larger particles ground over again.

The process of pulverizing German silver solder, as just described, is a very troublesome one, as it not only requires a great expenditure of strength, on account of the tenacious nature of the alloy, but must be done within a short time, that is, while the metal is still hot. The following method of preparing the powder is preferable:

A cast-iron mold is made, in two parts exactly fitting together, and allowing the casting of a cylinder 20 or 30 centimeters long and 8 or 10 in diameter. This cylinder is rubbed on the inside with oil and lampblack, to prevent the alloy from adhering, and filled with the metallic mixture. After it has become entirely cold, the cylinder is placed in a mechanical turning lathe, and the turning chisel so adjusted that very fine filings are shaved off, which are then heated and pulverized. The cylinder may also be pressed against a rapidly-revolving steel disk, cut like a file, and the filings procured in this way.

Silver Solders.

The solders which contain silver are very strong and tenacious, and are used not only to solder silver, but also for other metals, in cases where the objects to be soldered require great power of resistance. Two principal kinds of silver solder are distinguished, hard and soft, the former consisting of silver and copper, with sometimes a little zinc, and the latter conthining, besides the metals just mentioned, a small amount of tin.

Hard Silver Solder.—According to the purpose for which this is intended, different compositions are used varying in fusibility. Silver workers use different solders for alloys of varying degrees of fineness, and the same ones are not always employed for re-soldering as for the first soldering.

Silver Solders.

Very Hard (for Fine Silver Articles).

Copper	1
Silver	4

Hard.

I.

Copper	1
Silver	20
Brass	9

II.

Copper	2
Silver	28
Brass	10

Soft.

I.

Silver	2
Brass	1

II.

Silver	3
Copper	2
Zinc	1

III.

Silver	10
Brass	10
Tin	1

These solders serve principally for completing the soldering of silver articles done with hard solder, by retouching imperfect places. Some silver workers use for this purpose copper and silver alloys mixed with zinc, as for example, the following:

Copper	4
Silver	12
Zinc	1

Or,

Silver	5
Brass	6
Zinc	2

The latter is readily fusible, but also rather brittle, and is frequently used for soldering ordinary silverware.

Solders for Iron, Steel, Cast Iron and Copper.

I.

Silver	10
Brass	10

II.

Silver	20
Copper	30
Zinc	10

III.

Silver	30
Copper	10
Tin	0.5

Soft Silver Solder.

Silver	60
Brass	60
Zinc	5

In the case of solders which are prepared with brass, care should be taken that neither of the metals in the composition contains iron, as it has been found by experience that the presence of a very trifling amount of this is sufficient to change the character of the alloy materially, making it brittle.

Silver solders are used in the form of fine filings or wire, the latter method of preparing it being especially adapted to the tenacious and ductile nature of the alloy.

In the large manufactories for silver ware it has become the custom in recent years to use the same alloy for soldering as that of which the silver article is made. It is used in the form of filings, and melted into the seams so that the object and the solder are really homogeneous.—Translated from Edmund Schlosser's "Das Löten der Metalle."

DISSOCIATION OF MATTER UNDER THE INFLUENCE OF LIGHT AND HEAT.

IN a memoir recently presented to the French Academy of Sciences, Mr. G. Le Bon draws attention to an interesting fact brought out by his experiments on the dissociation of matter, viz., that under the action of light two rather different phenomena will be superposed upon each other. While dissociating matter, light will, in fact, exert another effect. Whenever its intensity is sufficient to heat the substance exposed to its action, a small amount of radio-active elements, as contained by all substances owing to their spontaneous dissociation, is expelled.

In order to demonstrate the latter action, the ball of a charged electroscope should be surrounded with a thin metal cylinder, arranged like the usual cap of this instrument. If, then, the cylinder be exposed to the sun in summer, the gold leaves will be found to approach each other by some degrees. The discharge is, however, soon stopped entirely, in order again to begin only after the metal struck by the solar rays has been exchanged.

Identical results are obtained if a body heated to a temperature of 782 to 932 deg. F., or say, the gases of a flame conveyed by a pipe into the neighborhood of the cylinder, be approached in the dark to a distance of an inch or two from the cylinder surrounding the ball of the electroscope. A discharge corresponding with about 100 volts in three to four minutes will then be observed. The same phenomenon may be repeated several times. After a very short time the metal, however, ceases working, in spite of any cleaning or washing it may have been submitted to, but after a few weeks of rest it resumes its virtue of discharging the electroscope.

When investigating the causes of this rapid loss of its properties under the influence of a heat raising its temperature only by about 68 deg. F., the author stated that it was due to the expulsion, under the action of heat, of a certain amount of radio-active particles, as formed spontaneously in all bodies, and which are recovered by rest whenever lost.

The above experiment fitly illustrates the universal radio-activity of matter. In fact, all bodies have been found to possess, to a very slight extent, it is true, the properties shown to such a high degree by radium and uranium.

Metals tend to lose their faculty of giving out radioactive particles, not only under the influence of heat, but as well, though to a smaller extent, whenever they have undergone for some time the action of light, even in case the source of light has not raised their temperature to any marked degree. After first giving a practically instantaneous discharge at the electroscope under the influence of the light rays thrown on its surface, a metal will eventually act more and more slowly. Ramsay and Spencer recently investigated the same phenomenon, which they call a "fatigue" of the metal due to the action of light. The numerous diagrams given by these experimenters afford an adequate idea of the behavior of this phenomenon, ascribed by them to an alteration in the equilibrium of the atomical surface elements, as a consequence of the loss of a certain amount of electrons due to the disintegration of matter.

According to a recent report of the Swiss Postal and Railroad Department, the circulation of trains has constantly increased within the last few years upon the main line of the St. Gothard Railroad. The increase of traffic made it necessary to have numerous crossings upon the single-track sections, so that it became from day to day more difficult to observe the exact time upon these sections. Consequently the time has come for building a second track upon the sections of Lucerne-Immensee, Brunnen-Fluelen, and Giubiasco-Chiasso, if the running of the St. Gothard line is to correspond to what is expected of an international trunk line. However, the building of a second track will encounter very great difficulties upon some of the sections, and it seems the best plan to distribute the work over a rather long period. In consequence, the Federal Council, upon the above-mentioned report and in application of article 14 of the federal law of December 23, 1872, concerning the operation of railroads, took the following decision, that at the present time a second track should be laid upon

the Giubiasco-Chiasso section, and a side-track upon the Lucerne-Meggen section. The St. Gothard Railroad Company are to submit to the Railroad Department within a short time the construction plans relating to this work. The Federal Council will reserve until a later date its decision upon the construction of a second track upon the Lucerne-Immensee and the Brunnen-Fluelen sections.

A NEW KRIEGER GASOLINE-ELECTRIC OMNIBUS FOR USE IN PARIS.

By the Paris Correspondent of SCIENTIFIC AMERICAN.

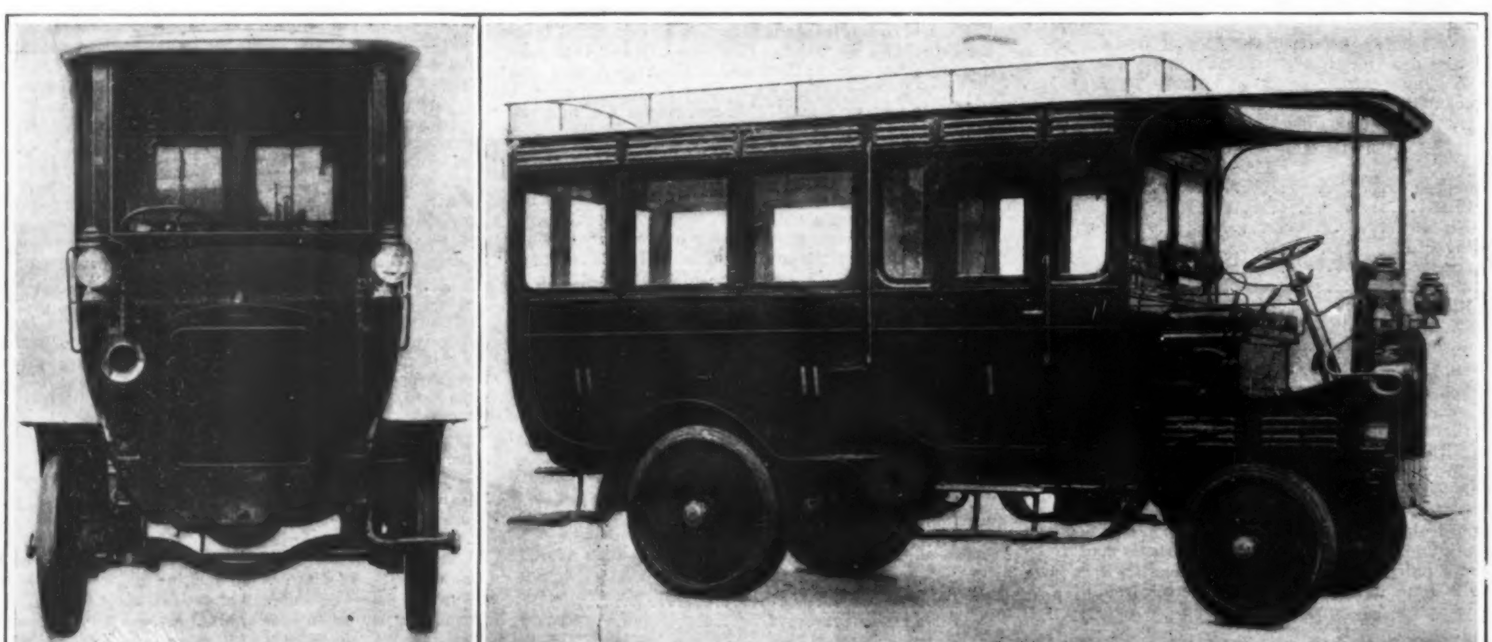
AFTER applying the combination gasoline-electric system very successfully to the standard types of automobiles, the Krieger Company, of Paris, has recently brought out a large omnibus which is designed to replace the horse vehicle for the regular city service. As to the principle which is used for operating the present car, it is the same as has been in use for some time past on the smaller types of Krieger vehicles, and we have already had occasion to describe some of these automobiles. It will be remembered that an electric motor with single-reduction gearing is mounted on the rear axle in such a way that the small pinion of the motor engages with a large gear which is bolted against the inner side of the driving wheel. Thus each wheel of the car has an independent motor, and as the motor speed can vary it will be seen that a differential mechanism is not needed for the rear axle. This makes the system a very simple one and it has many advantages. On an ordinary electric car a storage battery is used to drive the motors, but on the combination gasoline-electric system the current is furnished by a small dynamo which is coupled to the shaft of the gasoline motor.

As will be noticed in the two engravings, one of which shows a side view of the new omnibus and the second a front view of the same, the car presents a handsome appearance, and in this respect it is much superior to the double-decked omnibus, such as is adopted as a standard upon the Paris lines and has even been adhered to in the design of the new gasoline omnibuses which are commencing to circulate. The double-decked car has a disadvantage in that it cannot be driven at as high a speed as a lower car of the type which we show here. First and second-class compartments form the body of the omnibus. The front, or first-class compartment, holds six persons seated, while the second-class compartment in the rear has seating room for twelve persons, making eighteen places in all.

The driver sits above an elevated platform, and below the platform is lodged the motor, just above the front axle. Good means of ventilating the motor are provided, although it is well inclosed by the car body at the top. The motor is of the Georges Richard-Brasier type and follows the lines of the well-known standard car motor. It has four upright cylinders cast in pairs. The cylinders have a 4.2-inch bore and a 5-inch stroke, and when running at the usual rate the motor can give 24 horse-power, which is found sufficient to drive the omnibus, seeing that it runs at a comparatively slow speed. Back of the gasoline motor is placed a dynamo arranged to give a constant output. The dynamo is direct-connected to the shaft of the gasoline motor by means of a friction clutch, the operating lever of which is beside the driver's seat. In this way the dynamo furnishes current for the motors, and the circuits of the dynamo are first brought into a controller in the from of a drum, designed on the lines of an electric car controller, but placed horizontally and lodged under the driver's seat. It is operated by a lever which projects at the right-hand side. From the controller, the different circuits pass under the car by covered cables to each of the motors. In the case of the omnibus, since the load is much heavier than usual, thus necessitating a heavy motor torque in starting, double-reduction gearing is used from the motor to the rear wheels, in place of the single-reduction which is found sufficient for the lighter cars.

The motor used is built on the standard Krieger pattern, and it has four poles, two of which are compound-wound. The field and armature circuits of the motors go to the controller, and by the proper coupling of these a number of speeds can be given to the motors, as well as the reverse motion and the electric brake. The latter is obtained by making the motors work as dynamos when the car runs down grade, thus causing them to do work and slow up the car. In this case the armatures of the motors are short-circuited. This braking operation, which needs to be quickly carried out, is operated by a special pedal. Besides the electric brake, there are three mechanical brakes, of which the first is a brake shoe applied to the wheels against the inner side of the gear wheel. The second brake acts upon one of the shafts of the gearing, while the third is placed upon the shaft of each of the electric motors.

In the front view of the car will be noticed the method of mounting the radiator, and also the arrangement of the front axle and wheels. The axle is curved in the middle so as to clear the motor crank case. Besides the steering wheel and the controller lever, the driver has at hand a lever for operating the gas inlet for the motor, so that he can change the speed of the car in this way, while leaving the electric connections the same. He also operates the brake lever for the main wheel brakes, two pedals for the other brakes mentioned above, and a pedal for the electric braking system. The action of the latter cuts off the current from the motors at the same time.



THE NEW KRIEGER GASOLINE-ELECTRIC OMNIBUS NOW IN USE IN PARIS.

THE POSITION OF THE SUBMARINE.

THE building of very big warships enhances the value of very little warships; and that brings to the fore the policy of constructing submarines. If a small, cheap boat, like a submarine, stands as good a chance of bagging a $10,000,000 "Dreadnought" as she does of exterminating a $5,000,000 "Majestic," then the efficiency of the small boat is distinctly advanced. So much being evident, the question remains, What is the chance? That it is considered to be an increasing one may be gathered from the fact that every first-class power is devoting greater attention to the acquisition of a satisfactory design of submarine boat; and shows more readiness to provide money for the building of such craft. It is therefore opportune to consider the whole question in connection with the details of the past year's work in our own navy given in another article in this issue, and of the great advance lately attained, as a consequence of research work, in propelling machinery for submarine use. We have in commission, or in course of construction, over forty submarines; but in view of the activity of foreign powers it is more and more to be regretted that the Admiralty reduced the number to be laid down during the current financial year from twelve to eight, and the facts since disclosed strengthen the objection to this course which we expressed at the time.

Our chief rival in the possession of weapons for submarine warfare is France. The French government were ahead of us in adding submarine boats to the navy of the republic, and now holds the superior position so far as numbers are concerned. According to an Admiralty return, France had thirty-nine submarine boats completed last spring—as against our twenty-five—and fifty building, or projected, as against our twenty-three. Some of the French boats appear, on paper at any rate, far more powerful than our own. Thus the French had eighteen boats in construction, of a displacement of 391 tons, each fitted with no less than seven torpedo tubes; while there were six others under construction, each of 383 tons, and having six torpedo tubes. Our own boats of the "C" class, of which there are eleven building, are of 313 tons, and have but two tubes each, although they each carry four torpedoes. There is every probability, however, of a considerable increase in the size and power of the new British boats.

The British fleet of submarine boats has, however, the great advantage of being composed of homogeneous groups, while the French vessels are a very mixed collection. How far this would affect tactics in this entirely new field of warfare it is difficult to say, but it is probable that it would have a considerable influence. The original idea of operation with the submarine boat was that a single one would creep out and catch the battleship or big cruiser unawares. The same theory was held when the torpedo boat first came to the fore, but it was speedily found to be ill-founded; both maneuvers and the small amount of war experience that has accrued have shown that attack in group is the proper maneuver. Of course, if the torpedo boat could make reasonably sure of surprise, and of the trustworthiness of its weapon, the single-unit attack would be the most profitable; but concealment until within torpedo range is by no means to be depended upon; and thus when attacking in groups a second or third may get its blow home while attention is being devoted to one or two others.

With the submarine the details are different, but the ultimate principle is much the same. The submarine has a means of concealment denied to the torpedo boat, but she is very much slower, and when she takes advantage of her means of concealment, by submergence, she cripples her power of attack enormously in some respects. It may be concluded that no belligerent vessels during any future war will lie at anchor, unless in a well-protected harbor, or in water so far distant as to preclude the possibility of submarine attack; we have, therefore, only to consider maneuvers under steam. An American naval officer, who has made submarine vessels a study, has said that "the submarine, *when within torpedo range*, is superior to the battleship, since the battleship is vulnerable to the torpedo—the weapon of the submarine." This writer, Lieut. Halligan, does well to emphasize the words he puts in italics; but even when within torpedo range the submarine has not victory assured. Torpedoes fired from a submarine do not always hit their mark, although the application of the gyroscope has done wonders in adding to their trustworthiness. A British boat having four torpedoes on board, or a French boat with seven tubes—we are not aware how many torpedoes the latter vessels carry—might have a further chance; but unless the torpedo were to be fired at random, the boat would have to come to the surface again to sight for a second shot, supposing that the ship had not, in the meantime, steamed out of range.

In order to make an effective attack upon a ship under way, it is necessary that the submarine boat should intercept the vessel in her course. The legend surface speed of the "C" class of British submarines is 13 knots, and their submerged speed for three hours is put down at 8½ knots. These are really remarkable rates of traveling for vessels handicapped in the manner submarine boats necessarily are, but it is anticipated that the "D" class will make 15 or 16 knots on the surface and 9 knots submerged. Some of the forthcoming French boats have been assigned 13 knots and 8 knots respectively for surface and submerged speeds, while the two most recently projected vessels are intended to have 15 knots and 8 knots; but the designs are not yet complete.

We will suppose, however, that a submarine boat has reached the 14-knot and 9-knot standard. If the boat

were to sight a hostile ship approaching directly toward her at 16 knots when at a distance of four miles, it would take a quarter of an hour for the ship to reach the submarine, supposing the latter to be stationary. That would be a piece of great good luck for the submarine, and, though it might occur, the probability is hardly great enough for it to be depended upon. We will suppose, however, that, in place of the boat being right in the enemy's path, the ship is steaming on a course that would pass the position occupied by the submarine at the time of sighting at a distance of two miles, the distance at which the ship was discovered being again four miles. The submarine would have her enemy as she sighted her 30 deg. before the beam. To take a simple case: if the boat, traveling at 9 knots, made directly for the course the ship was pursuing, it would take her rather more than thirteen minutes to do the two miles which would bring her to a point cutting the ship's course, or, say, nearly thirteen minutes to come within torpedo range. In the meantime the ship would have been occupying about the same time to cover the three and one-half miles that would lie between her first sighted position and the point where the two would meet. Under these circumstances, the submarine would be within striking distance, and able to fire one torpedo.

The tactics are not necessarily those that would be pursued, but the original conditions supposed are favorable to the boat; that is to say, the luck would be in her favor. No time has been allowed for her filling her tanks to assume the submerged position, and she is supposed to have maintained a direct course. What part of the run would be made under water would be a matter for the discretion of the commander, who would be governed by the light and the conditions of weather; but it would be wise to keep the conning tower above the surface as long as possible, because it is difficult to keep an object in sight by the periscope, and also extremely difficult to judge distance. The conning tower awash, however, makes the position of the boat visible by the wave it creates—a more noticeable thing than the tower itself in some states of the sea and atmosphere, when the boat is traveling at high speed.

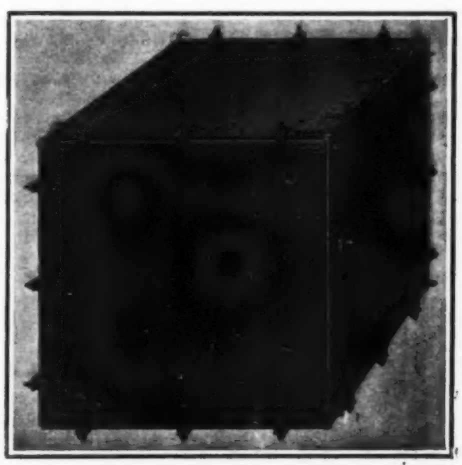
In ordinary daylight the ship would be seen by the submarine at a greater distance than eight miles, but it must be remembered that, even when the boat is highest out of water, the deck is elevated only a few inches above the surface. Standing on the top of the conning tower, a man would have an horizon distance of not much more than three and one-half miles, while a height of 50 feet gives only slightly over an eight-mile radius. In daylight, however, there would be a greater chance of the submarine being sighted; and in that case the ship would alter her course so as to avoid the slow-moving submarine; for at present it is doubtful whether any effective means have been devised for a counter attack on these boats when they are below the surface. The most promising suggestion has been the use of small torpedoes with light charges, sufficient, however, to fatally damage so vulnerable a structure as a submarine boat. As they would deal with slow craft, these torpedoes need not be so fast as those used for swifter ships. They could be carried by boats and easily handled. Of course, there is one chance of going over, as well as under, the submarine, even if her position were known; but the torpedoes would be comparatively cheap, so that a fair number might be expended; and if the submarine had been sighted and were known to be attacking the ship, her position could be very fairly estimated, as her lack of speed does not give her much choice. The value of torpedo boats, destroyers, and pinnaces to act as vedettes for discovering submarines and attacking them with quick-firing guns, or with light torpedoes, will be understood. Even if the small craft could not injure the submarines, they might prevent them from coming up to take observations, and thus frustrate their object.

The improvement in the design, and consequent advance in efficiency, of the submarine boat has been a remarkable feature of recent naval history. The various naval authorities concerned have, however, so well kept their secrets that there is not much to say on the subject. At the meeting of the American Society of Naval Architects and Marine Engineers, held in New York last month, an instructive paper on "The Development of Submarines" was read by Mr. L. Y. Spear, a member of that society. In this paper are given some interesting particulars of a trial of the submarine "Fulton," as carried out by the United States Navy Department last June. The "Fulton" was of the "Adder" class, but has been somewhat altered and much improved in detail since she was built. The "Adder" is a single-screw boat, with the usual gasoline and electric means of propulsion. She is 64 feet long by 11 feet 9 inches beam, and displaces submerged 122 tons.

The programme was for the "Fulton" to leave Newport harbor and proceed at full speed in the light condition to a stakeboat anchored in the open sea. She was there to submerge and find a target 10 nautical miles distant to seaward. This target consisted of two ships' cutters 300 feet apart, and marked by a yacht 250 yards west of the target. All observations during this attack were to be made by the periscope. As it was feared torpedoes might be lost, the "Fulton" was simply required to expose her periscope within torpedo range, and then, submerging the periscope, to pass through the target. She was then to return submerged and pass round a stakeboat three miles distant and again attack the target, this time making observations from the conning tower only, the eye-piece of the periscope being removed. She was then to return submerged over the course, pass to the light condition, and proceed under her main engines, charging batteries while under way. After charging batteries she was to remain submerged for twelve hours. The whole trial was to continue for at least twenty-four consecutive hours, during which the vessel and crew were to be entirely self-sustaining.

HELMET OF DE PLUVY DIVING SUIT.

These were the conditions laid down, and the "Fulton" more than fulfilled them. She was submerged fifteen and one-half hours out of the twenty-four; during the remaining eight and one-half hours she was cruising on the surface. During the twelve hours' continuous submergence the full crew and one observer were on board, and no fresh air was supplied until the end of the test. The average depth maintained during the attack was 20 feet, which was sufficient to entirely submerge the periscope. During the ten-mile run to the target the periscope was momentarily exposed at intervals of about two miles; the boats, on account of their small elevation, were difficult to pick up. The final observation was made at a distance of 825 yards from the target.



THE COLLAPSIBLE CAISSON.

These particulars of an interesting trial give a very fair account of what a submarine boat can accomplish. How the trials of our own craft would compare with the run of the "Fulton" we have no means of knowing. There is little doubt, however, that the submarines of the royal navy are second to none, and are probably in advance of all others.—Engineering.

THE DE PLUVY DIVING APPARATUS.

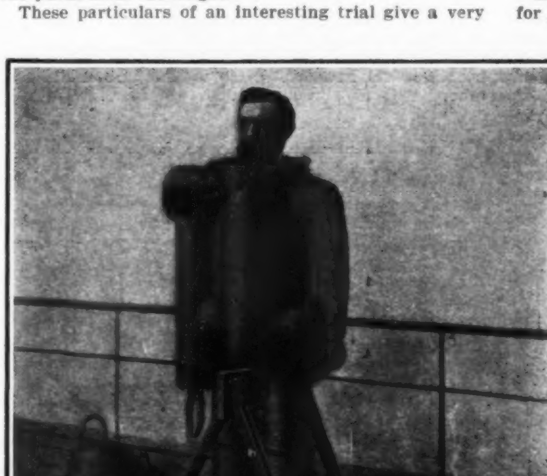
By the Paris Correspondent of SCIENTIFIC AMERICAN.

AN important advance in the way of exploring the ocean depths has been made by M. De Pluvy, a prominent hydrographic engineer and an experienced diver, consisting in a suit of metallic armor which will resist a great pressure and thus give the diver the means of going down to a great depth in the ocean. The apparatus uses electric devices to a great extent. At present we have been limited to about 40 feet depth in the ocean, and after this point we have but little knowledge of the ocean bed except what the sounding line reveals to us. A new field of research will be opened up from now on, and besides, we will be able to explore wrecks which lie on the sea bottom. It is especially for this latter purpose that M. De Pluvy set about to design his apparatus, and after a number of successful trials with it a company was formed at London and Paris for operating it in connection with recovery of wrecked vessels. M. De Pluvy is able to go down to a depth of 100 meters (330 feet) with his metallic armor suit. In person he made as many as 115 descents at depths varying between 100 and 330 feet and at the latter depth he explored the ocean bed and made many observations which have both a scientific and a practical interest. He has been working on the subject for the last five years, but it is only recently that he succeeded in building the present form of armor suit. It contains besides an automatic air-renewing device attached to the helmet and worked by small electric motors contained therein. The cable which connects the diver with the boat serves to conduct the current for the motors. Electric light is used at these great depths, as it is otherwise too dark to distinguish objects.

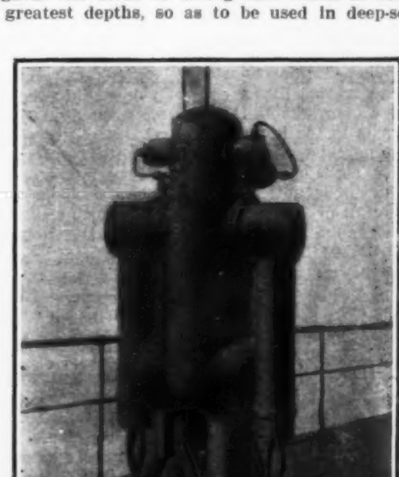
Up to the present a diver generally stayed below for three hours at most, and if he went below 30 feet, or one atmosphere pressure, the need of respiration and the fatigue obliged him to come to the surface almost at once. This caused a loss of time, and often on the second descent he found his work undone by the action of the elements. Such work besides is always attended by some danger, and it is a slow operation to raise the diver to the surface. With the new device almost all these difficulties are overcome, and the diver can remain below for four hours and even more. At any depth he has no bad effects from the irregularity of the air-pump supply. Work once commenced can be arranged so as to be continued by another diver at once, and by means of the telephone the latter is kept informed as to the progress of the operations.

The diving apparatus which has been designed by M. De Pluvy is constructed at present in several different types according to the depth at which it is desired to work. It can be used in the seas, lakes, or rivers at variable depths which can go as low as 300 feet and over. As will be noticed in the illustrations, the apparatus consists of a diving suit which is entirely made of metal, and somewhat resembles a suit of armor, except that there are a smaller number of joints. The helmet is one of the main features of the diving suit and contains the means for renewing the supply of oxygen to the diver without needing any air tubes running up to the surface, which is one of the advantages to be secured here.

As regards the form of diving suit which is built for the greatest depths, so as to be used in deep-sea



THE HELMET AND ONE ARM PIECE REMOVED.



READY FOR THE DESCENT.

THE DE PLUVY DIVING DRESS AND CAISSON.

work, some details have been given by M. De Pluvy about his special method of construction. The armor suit for depths down to 300 feet is built of sheet iron having a thickness varying between 0.02 and 0.04 inch according to the nature of the pieces. A special point in the armor is the joints, and these have to be

very carefully made in order to work well at these great pressures. He uses a form of hydraulic joint which is made of leather combined with rubber, and it is found to answer the purpose very well. A whole suit of armor of this kind weighs about 550 pounds. For the apparatus which is intended to be used at medium and shallow depths, the thickness and weight can be very much reduced according to each case, but as a precaution he constructs each suit so that it can stand double the pressure at which it is to be used.

The helmet is joined to the main part of the armor by a special pressure joint, but it is always easy to remove and replace. On each side of the helmet, which is provided with two glasses for the eyes in front and a third on the top, is fitted a cylinder communicating with the inside. One cylinder contains the apparatus for bringing the air into the helmet and the other is fitted with an exhaust device. In the rear the helmet carries a separate cylinder which connects with each of the others by a tube lying at the outside. This cylinder is of some size and contains a number of compartments which are filled with a chemical substance so as to renew the air. In this way the air which is expelled from the lungs is drawn by an exhaust fan (driven by an electric motor) placed in one of the side cylinders and from thence it passes by the outer tube to the renewing cylinder in the back. After being freed from carbonic acid and given a fresh supply of oxygen, the air passes into the other side cylinder by the tube and thus enters the helmet so as to be breathed by the wearer. In this way there is kept up a continuous circulation in the cylinders and the body of the helmet without any connection with the outside, and the carbonic acid is constantly absorbed and a fresh supply of oxygen given to the air in a closed cycle. Care is taken to provide a well-designed regulating device in the cylinders, so that just the right amount of oxygen is given to the air, seeing that this is an important point. M. De Pluvy has designed an automatic regulator which allows the circulation to be kept up for many hours at a time without any perceptible change in the quality of the air.

A proper arrangement of joints and bearings attaches the arms and legs to the main body of the armor suit, and the whole device allows the diver to make any kind of a movement very freely and with but little effort. It will be seen that the method of renewing the air is the characteristic point of the apparatus, and it suppresses all the disadvantages of the old devices in which the air is sent down from above by piping. Another point is that the air sent from a pump is apt to arrive by a series of impulses, and moreover it is often overheated on account of the continuous working of the pump. In the present case the pressure inside the helmet is always kept at atmospheric pressure by means of the regulators no matter what may be the depth at which it is used.

A specially-equipped boat is employed for this purpose, and it contains the devices for raising or lowering the divers in the water and also for keeping up a telephone connection with them and supplying the electric motors in the cylinders with current. A cable drum operated by an electric motor raises or lowers the diver, and the cable serves at the same time to carry the current into the helmet. There is also a second or safety cable along with the first. The diver can have connection with the surface for signaling both by means of a telephone which is easily fitted within the helmet and also by a set of signal lamps placed on the boat. A board or rack is fitted with a number of different-colored lamps from which a set of wires formed into a cord run down into the inside of the diving suit so that the man can send any desired signals to the boat according to the code agreed upon, and he thus reports how the work is progressing or gives signals for raising or lowering, etc. Another point to be noticed is that there need be no fear of entering or leaving the apparatus as regards the sudden change in air pressure, and this can be done instantly, while with the usual diving suit, besides having to draw up very slowly, the diver must exercise great prudence in coming out of the water and have some experience in order to support the pressure of air in the lungs.

ORIGIN, OCCURRENCE, AND CHEMICAL COMPOSITION OF PEAT.*

By W. E. McCourt.

The term peat has always been more or less loosely used. In some localities the name has been given to a black earthy soil which, in reality, is simply a muck. Peat is a brownish to black deposit formed by the accumulation and slow decay of vegetable matter under water, in bogs and swamps. It may be, in some cases, the incipient stage in the formation of coal and a chemical gradation can be traced from peat to anthracite. The following analyses† show this relation:

Substance.	*C*	*H.*	*O.*	*N.*	*S.*	*Ash.*	*Sp. gr.*
Peat,	54.02	5.21	28.18	2.30	.56	9.73	.850
Lignite,	66.31	5.63	22.86	.57	2.36	2.27	1.129
Bituminous coal,	78.69	6.00	10.07	2.37	1.51	1.36	1.259
Anthracite,	90.39	3.28	2.98	.83	91	1.61	1.392

Peat is often fibrous, though in some varieties but few fibers may be distinguished. The main peat-former is a kind of moss known as sphagnum, though other water plants as sedges, grasses, and the like may make certain varieties. The process is one of slow oxidation, out of contact with the air, in which the amount of carbon increases as the volatile elements like oxygen and hydrogen decrease.

The following analyses* show the variations which take place in the change of the sphagnum to peat:

Substance.		*Analyst.*	*Carbon.*	*Hydrogen.*	*Oxygen.*	*Nitrogen.*
Spagnum,	Unaltered.	Websky,	49.88	6.54	42.42	1.16
Peach wood,		Chevandier,	49.90	6.10	43.10	0.90
Poplar wood,		"	50.30	6.30	42.40	1.00
Oak wood,		"	50.60	6.00	42.10	1.30
Peat, porous, light brown, spagnous,		Websky,	50.86	5.80	42.57	0.77
Peat, porous, red brown,		Jaeckel,	53.51	5.90	40.59	
Peat, heavy, brown,		"	56.43	5.32	38.25	
Peat, dark red brown, well decomposed,		Websky,	59.47	6.52	31.51	2.51
Peat, black, very dense and hard,		"	59.70	5.70	33.04	1.56
Peat, black, heavy.	Best quality for fuel.	"	59.71	5.27	32.07	2.59
Peat, brown, heavy,		"	62.54	6.81	29.24	1.41

A good peat bog usually shows the following section: On the top is a layer of the living plants, below this is a mixture of partly-decayed plants containing well-defined fibers, and at the bottom is the typical spongy peat in which fiber may be totally absent.

Peat may vary considerably in color, structure, consistency and composition. The well-decomposed varieties are usually of a black color, more or less spongy and waxy and contain few or no fibers, while the younger peats are more brownish, fibrous, and rather loose in texture.

Peat bogs are usually met with in temperate, cold, and humid climates, for "as we advance toward the warmer climates, vegetable matter is more rapidly decomposed, until, at the tropical regions, the putrefaction of animal and vegetable matter is so rapid that it prevents the formation of any body of the substance and structure of peat."† Besides, in temperate regions, evaporation is slow and the sphagnum, which is the greatest source of peat, does not flourish in dry air.

Peat accumulates in marshes and swamps where the drainage is so hindered as to prevent complete decay of the vegetable matter which may have been deposited in the water. The various kinds of marshes and swamps may be divided into two classes:

1. Marine marshes.
2. Fresh-water swamps.

Marine marshes are formed along the coast, in bays and protected harbors. Large tracts of this type border the coast of New Jersey. These areas are covered with marsh grasses which gradually decay and accumulate with a fine mud, but the resulting deposit is not usually a good peat and is commonly of little use as a fuel, though some of the deposits may be used for packing or as a litter, or even as a fuel.

Among the fresh-water swamps the commonest and perhaps the most important is the lake swamp. In the north temperate regions there are many lakes and ponds the shores of which are lined with water plants, chiefly mosses. By the growth of these plants the motion of the waters is oftentimes retarded, the shores are kept free from the beating action of the waves and the fringe of plants may spread out over the surface. In time, the entire surface of the water may be covered by this growth. At the same time there will also be a vertical growth, for some plants will die and others will take root on their remains. With this covering of moss as a basis, other plants, like ferns and grasses, will take root and constantly add to the vegetable accumulation. The deposit will grow deeper and deeper and heavier plants and even trees will spring up to add to the mass. So the lake or pond may become entirely filled with a mass of fibrous vegetable matter, which on top will show living plants and below will pass into the waxy peat in which no fiber may be present.

There are other types of swamps in which more or less pure peat may be formed. Swamps may be formed along rivers on terraces and flood plains and, during times of high water when these depressions are covered, water plants may grow, decay, and accumulate to form a deposit of muck or impure peat. Another type is the delta swamp, which may be formed in a lake in which there will be found a deposit of a black soil containing vegetable and mineral matter. Or a delta swamp may be formed along the seashore and here the deposit would be much like that which is formed in tide-marshes. Other minor types like the swamps in kettle holes and on uplands may be centers of peat accumulation.

In all these swamps the deposit will grow deeper and deeper, the process of slow oxidation will take place with the evolution of hydrogen, oxygen, and some nitrogen in the form of carbon dioxide (CO_2), marsh gas (CH_4), and water and the deeper portions will become more compact and spongy. A covering of water is necessary, for if the vegetable matter were exposed to the air it would be completely destroyed.

Peat, when dug, contains a considerable amount of water. The percentage may be as high as 85 per cent, or even higher. When the peat is put out to dry it loses a large amount of this water, but never dries thoroughly. In the case of the New Jersey peats the moisture in the dried samples ranges from 4.93 per cent to 24.30 per cent, with an average of 15.52 per cent.

All peats contain mineral matter which was deposited with the vegetable matter. This, upon the burning of the peat, is left as ash. The peats which contain a large amount of ash (50 per cent or more) are given the name muck and are of little avail, except for agricultural purposes. The percentage of ash in good fuel peats varies from 3 to 10 per cent, though in some cases it may run as high as 25 per cent, the amount depending upon the quantity of sediment deposited while the peat was accumulating. The New Jersey samples tested ranged from 5.04 per cent to those having over 50 per cent.

The following table shows the ash percentages in some of the peats from New Jersey and other States:

Cranston, R. I.[1]	13.00	Beavertown, Ont.[6]	6.68
Woonsocket, R. I.[2]	1.80	Beavertown, Ont.[6]	27.67
Wickford, R. I.[1]	12.00	Ardennes, France[7]	8.30
Bedford, N. H.[2]	7.00	Allandale, N. J.[8]	5.88
Bedford, N. H.[2]	4.60	Newton, N. J.[8]	12.03
Rochester, N. Y.[3]	2.15	Lafayette, N. J.[8]	12.75
Rochester, N. Y.[3]	3.05	Sussex, N. J.[8]	13.61
Rochester, N. Y.[3]	5.08	Rockport, N. J.[8]	13.83
Colebrook, Conn.[4]	4.57	Stockholm, N. J.[8]	6.97
Poquonnock, Conn.[4]	5.92	Dunker Pond, N. J.[8]	7.59
Poquonnock, Conn.[5]	8.63	Ironia, N. J.[8]	16.52
Welland, Ont.[6]	4.07	Great Meadows, N. J.[8]	13.97
Welland, Ont.[6]	7.17	Bog and Valley, N. J.[8]	13.46
Beavertown, Ont.[6]	16.20	Black Meadows, N. J.[8]	13.19
Beavertown, Ont.[6]	7.03	Troy Meadows, N. J.[7]	12.85

The ultimate analysis of various peats will also show considerable differences, but the main products are carbon, hydrogen, oxygen, and nitrogen, and these are the same elements present in the entire coal series and in the plants from which the peat is formed.

The average composition of peat, after deducting the ash mineral residue and recalculating, is:*

Carbon,	52 —56%
Hydrogen,	4.7— 7.4%
Oxygen,	28 —39%
Nitrogen,	1.5— 3%

In the following table there is given a number of analyses of peat from various sources and localities. These are published in the belief that they may be of some value to readers of the report who do not have access to previous publications on this subject. They do not include any analyses made in these investigations.

ANALYSES OF PEATS.

Locality.	Org. Matter	H_2O	Fe_2O_3 Al_2O_3	CaO	MgO	K_2O	Na_2O	P_2O_5	SO_3	CO_2	SiO_2	Authority.
New Jersey—												
Black Brook Meadows, Columbia Turnpike, Morris County,	65.61	16.16	3.19	3.86	.37	.31	......	.93	.89	.09	8.64	Cook, Geol. of N. J. 1868, p. 481.
Columbia, Morris Co.,	66.87	15.15	3.97	3.17	.39	.27	......	.1	2.46	......	7.63	" " " "
Allandale, Bergen Co.,	83.8	11.7	.42	1.46	.17	.08	......	.05	.74	.04	1.07	" " " "
Beavertown, Morris County,	69.8	16.8	2.92	3.34	.27	.02	......	.19	.76	.43	5.36	" " " "
Michigan—												
Meare near Bridgewater,	97.78	......	.536	$CaCO_3$ .855	.144	.131	.065	.053	.051	......	.403	Mich. Ag. Rept. 1865, p. 208.
Ohio—												
J. F. Brooks, Salem,	......	91.31	Fe_2O_3 .33	$CaCO_3$ 1.24	......	1.26		......	......	......	5.86	Ohio Ag. Exp. Sta. Rept., 5:281.
Wisconsin—												
Baraboo, 1st foot,	84.28	......	......	2.16	......	.11	......	.28	......	......	8.68	
2d and 3d foot,	92.00	......	......	1.5	......	.04	......	.1	......	......	5.39	

RHODE ISLAND.

Locality.	H_2O	Ash	Veg. Matter	SiO_2	Fe_2O_3 Al_2O_3	CaO	MgO	K_2O_5 loss.	Authority.
Cranston,	......	13.	87.	8.	2.2	2.8	......	tr	Jackson, Rept. on Geol. and Ag. Sur. of R. I., 1840.
Block Island,	25.25	6.35	63.4	4.5	.75	1.1	......	......	
Cumberland Hill,	......	2.15	97.85	.45	.25	1.3	......	1.5	
N. Kingston,	......	25.6	74.4	21.2	2.4	1.5	......	.5	
Pawtucket,	......	11.4	88.6	9.5	1.9	......	......	......	
Wickford,	15.9	11.5	72.6	8.9	1.5	1.1	.2	......	
Woonsocket,	10.	1.8	88.2	.5	.3	.6	......	......	
S. Kingston,	......	17.5	82.5	12.	2.1	2.5	.5	.4	

* Abstracted from the annual report of the State Geologist of New Jersey.

† Carter, Peat Fuel. Its Manufacture and Use. Report Ontario Bur. Mines, xii., 194; 1903.

* Johnson, Peat and Its Uses, N. Y., 1866, p. 24.

† Leavitt, Facts About Peat, Boston, 1867, p. 30.

[1] Jackson, Rept. on Geog. and Ag. Sur., R. I., 1840.
[2] Jackson, Geol. and Min. of N. H., 1844.
[3] Fairchild and Barnum, Pinnacle Peat Marsh, Proc. Roch. Acad. Sci., iii.
[4] Johnson, Essays on Peat, Muck and Commercial Manures.
[5] Jackson Rept. on Geog. and Ag. Sur., R. I., 1840.
[6] Carter, Peat Fuel. Ont. Bur. Mines, Bull v., 18, 1903.
[7] Taylor, Statistics of Coal.
[8] Parmlee, analyst.
[9] Ries, Uses of Peat and Its Occurrence in New York, Annl. Rept. N. Y. State Geol., xxi., 171, 1903.

OTHER ANALYSES.

Locality.	H_2O	Ash	Org. Matter	Authority.
New Hampshire—				
Bedford,	5.8	4.6	89.6	Jackson, Geol. and Min., N. H. 1844.
Canterbury,	13.7	23.4	62.9	" " " "
Lyndeborough,	21.	12.3	66.7	" " " "
Connecticut—				
Goshen,	20.33	8.	71.67	Johnson, Essays on Peat, Muck, and Commercial Manures.
Milford,	19.67	3.23	77.1	" " " "
Colebrook,	33.88	4.57	57.05	" " " "
Poquonnock,	17.2	8.63	74.17	" " " "
Rockville,	30.36	5.41	64.23	" " " "
New York—				
Rochester,	14.47	2.15	83.38	Fairchild & Barnum, Roch. Acad. Sci. Proc. III.
Rochester,	14.23	3.05	82.72	" " " "
South Salem,	19.43	21.27	59.3	" " " "
France—				
Ardennes,	30.5	8.3	61.2	Taylor, Statistics of Coal.

PEATS FROM ONTARIO.

Locality.	H_2O in Original Sample.	Calculated on 15% Water Content.			Authority.
		Volatile Combustibles.	Fixed C.	Ash.	
Welland,	81.2	59.27	21.66	4.07	Carter, Peat Fuel, Its Manufacture and Use.
"	87.48	56.78	21.05	7.17	Ont. Bur. Mines, Bull. 5, 18, 1903.
Beaverton,	62.98	57.13	11.67	16.2	" " " "
	83.21	67.58	10.39	7.03	" " " "
	84.06	73.6	4.72	6.68	" " " "
Perth,	......	54.72	19.85	10.43	" " " "
	......	57.81	18.92	8.27	" " " "
Brunner,	......	60.1	15.7	9.2	" " " "
Rondeau,	......	58.56	23.29	3.15	" " " "
Newington,	87.94	56.74	27.21	1.05	" " " "
	86.66	54.42	28.61	1.97	" " " "

These tables have been compiled from the following authors:

Ries, Uses of Peat and its Occurrence in New York, Annl. Rept. N. Y. State Geol., xxi., 163, 1903.

Parsons, Peat, its Formation, Uses and Occurrence in New York, Annl. Rept. N. Y. State Geol., xxiii., 32, 1904.

ELECTRICAL NOTES.

A novel process for the drying of peat by means of electricity has been designed by Count Schwerin, and is said to be used on a commercial scale. This process is based on the physical phenomenon of endosmosis, produced by an electrically-charged liquid flowing through a porous membrane. The wet peat is placed on a wire screen and covered with a lead plate, after which the electrical current is passed through the peat. Any water left in the peat after the compressing process will exude. Plants have been installed according to this process both in eastern and western Prussia. A steam engine stoked with peat dried according to the above process is driving a dynamo, which in turn supplies the current required for the drying process. The steam engine is said to use up only one-fifth of the dried peat for keeping up operation.

Engineers generally and especially most of those connected with storage-battery work, still look very unfavorably upon attempts to put the electrolyte within the electrode. The specifications of engineers usually stipulate the following conditions: Electrodes to be suspended, positives Planté, negatives of the Sellon type, acid space so much, space below plates so much, separation glass tubes, discharge down to so many volts (no matter at what rate of discharge), and so on. The introduction of the Niblett and similar cells has entirely revolutionized the mechanical construction of accumulators, enabling them to be constructed without plates, glass-tube separators, acid space, etc. An illustration of the difficulty engineers find in regarding storage-battery matters in other than conventional and stereotyped form was given recently.. An electrode of the network type was sent to a prominent manufacturer for him to test its capacity, efficiency, etc. The cubical contents of the network electrode included, of course, the acid-space within itself, but the manufacturer's engineer, who made the test, actually compared the electrode with an ordinary pasted plate (which, of course, does not include acid-space) for capacity, etc., in ratio to their cubical contents, without taking this important fact into consideration. The chief defect in the original construction of the Niblett battery was that there was no guarantee that electrodes do not consist for the most part of isolated pockets having no connection with each other, and so trap the gas and give no chance for adequate circulation of the electrolyte.

Various methods have been devised for changing alternating current into direct current so that the latter can be drawn from alternating current circuits and applied in many cases where it is essential, for instance, for charging storage batteries, for electro-chemical work, X-rays, medical applications, direct current motors, and many other uses. Such an apparatus must be of small size and not expensive, as it is to be used mainly on a small scale by private parties. Charging batteries for electric automobiles is one of the principal uses of such a device. The electrolytic method designed by O. de Faria, and exploited in Paris by the Ducretet firm, is said to be very good. It operates on the "electric valve" system, that is, making use of the already known property of an aluminium and lead electrolytic cell. When the aluminium forms the negative pole the current will pass, but when it is used as the positive pole the current is broken. This is due to the formation of a very thin layer of alumina which acts as an insulator, and the film is almost instantly formed and as quickly re-dissolved, so that by applying an alternating current to such an apparatus the waves having one direction are blocked, while the other waves are allowed to pass, thus giving current in one direction only. Cells have been already made on this principle, but do not seem to have met with much success, no doubt because they are apt to become polarized, and also heat up considerably. In the present cell the inventor claims to overcome these two defects by keeping up an automatic circulation in the liquid. The positive electrode consists of a lead cylinder, while for the active one a small aluminium cylinder or rod placed within the latter and near the bottom of the cell is used. A series of openings is formed in the bottom and at the top of the head cylinder, so that the heated liquid rises and is replaced constantly by cooler liquid, thus effecting a circulation of liquid which prevents polarization and overheating.

ENGINEERING NOTES.

While a difference of opinion may exist as to the type of superheater that is best, and which actual performance and observation up to the present has not determined, it is known that good results have been accomplished through tests made in foreign countries and in America, and the fact that superheating is a feature that must eventually enter into locomotive operation should induce American motive power men to give the matter more serious and immediate attention than has been done heretofore.

So far as has been learned at present, the lubrication of superheater engines is not different from that of other engines, with the exception that the lubrication must be accomplished, and it is not sufficient to hope that the oil gets to the designed spot. For this purpose a positive feed lubricator is required, and this should preferably be provided with six feeds, so that pipes may be led to each end of the valve and to the cylinder. It should also be possible to vary considerably the amount of oil fed per minute, as superheater engines, even more than those of the ordinary type, require more oil when working slowly at long cut-offs than at other times, on account of the high temperature of the steam being maintained throughout the stroke. This can be effected either by supplementary oiling or by an easy adjustment of the lubricator allowing a large amount of oil to be fed at low speed, but the latter will be preferable if obtained without complication. With proper lubrication there appears to be no additional wear of valves or pistons, and while a special mixture of metallic packing must be used, it has given, if anything, less trouble on the superheaters than on the other engines.

A firm which has lately entered the field for the construction of steam turbines is the United Augsburg-Nürnberg Machine Company, which is already well known on the Continent for metal work of different kinds as well as for steam engines, cranes and similar apparatus. As it possesses large and well-equipped factories it is in an excellent position to manufacture steam turbines, and it has already constructed a number of these, of different designs, which are now driving dynamos in different electric plants. The steam turbines are designed on the De Laval system, having a flat disk wheel with a series of concave blades at the periphery placed close together, with the steam nozzles lying on one side next the blades. A series of such disks is mounted on a common shaft and each disk lies in a separate chamber. The set of chambers and the disks form a complete turbine, but in some cases there is a high-pressure turbine which is connected with a low-pressure turbine by a steam piping, and the latter is made to pass underneath the bearing of the shaft which lies between the two turbines. Such machines are built in 3,000-horse-power sizes. For the smaller, 1,000-horse-power turbines, a single chamber is used which contains ten separate disk-wheels. Where dynamos are used with the Zoelly turbines, these are mounted upon the same base-plate as the latter, and make up a single unit. The oiling of the turbine bearings, which is an important point, is well carried out by an improved lubricating system, and a newly-designed speed-governor is employed, besides a safety regulator which shuts off the steam should the speed rise over 15 per cent above the standard. As an example we may cite the turbo-generator set which is installed in the Mülhausen central electric plant. It has a normal load of 2,600 horse-power and runs at 1,500 revolutions per minute. The inlet steam pressure is 170 pounds and the temperature 500 deg. F. According to the latest reports, turbines to the extent of 202,750 horse-power have already been constructed. At the Neu-Essen mines they erected a 3,500-horse-power machine, and another of 1,200 horse-power at the Burbach mines, both connected to dynamos. The Stuttgart municipal electric plant is using a 1,600-horse-power turbine, and in the Baku region of Russia a 1,500 horse-power unit is in operation.

It is a well-known fact that of the total quantity of gas generated in a blast furnace plant about 50 per cent is required within the plant. This includes losses at the furnace top and in pipings, viz.: for driving blowing engines, heating blast stoves, operating the cleaning plant, and generating electric energy in the central station, while the rest, representing an amount equal to 25 horse-power per ton of pig iron produced every 24 hours, is available for outside purposes or sale. Modern combined works often possess their own collieries and coke oven plants, which represent an additional source of available power. In modern by-product ovens the quantity of gas produced depends on the quality of the coal coked, on its moisture and on the type of oven, and varies considerably in composition during one coking period. Deducting 60 per cent for heating retorts and 10 per cent for driving plant auxiliaries, there remain available for every ton of coal coked in 24 hours, from 5 to 6 horse-power for other uses. The third source of energy previously referred to, namely, the gasification of culm piles, will liberate from every ton of culm charged in the producer in 24 hours about 25 horse-power, after deducting losses through deterioration, etc. That the total amount of useful power that can be gained by scientific transformation from the first two sources alone is no negligible quantity, will be seen when applying the above figures to American conditions. With an annual coke production of 35,000,000 tons in the United States, and utilization of the coke oven gases in regenerative ovens, there can be liberated with modern gas engines in the neighborhood of 1,500,000 horse-power, if a best consumption of 8,000 B.T.U. per brake horse-power is assumed. With an annual pig iron production of 25,000,000 tons the surplus blast furnace gases will generate in the neighborhood of 3,000,000 horse-power in gas engines. This large amount of surplus energy can, of course, be liberated only when gas power is employed for driving all machinery within the works. In small countries like Germany, England, and Belgium, the disposal of the available energy from iron smelting plants and coal mines offers no difficulty, owing to the close concentration of industrial centers. The power is partly used for electric distribution to other works or mines which have no individual power plant of their own but only possess transformer substations. Part of the energy is sent to neighboring cities for lighting and other purposes. In the majority of cases it is found advantageous to distribute the surplus energy in the form of electric current rather than as gas, though this practice cannot be generalized.

SCIENCE NOTES.

A dairy school has been established in Kingston, Canada, and is to be maintained by the Ontario Department of Agriculture, with a view to furthering the dairy industry of the province. Lectures on the science of dairying, bacteriology, and chemistry, with special reference to the chemistry of milk and its products, and practical work in cheese are the principal courses of lectures. Students are given thorough training in the judgment and selection of milk for cheese and butter making, and are taught the preparation, selection, and proper use of cultures. Much of the success in building up the dairy and cheese-making business of this vicinity to its present value and importance to Canada is due to the practical and efficient schooling of the students and the dairy farmers of the district. Aside from its shipping and commercial importance as a city and fortress at the terminus of the Great Lakes and the St. Lawrence River, one of Kingston's most important industries is the cheese-making and dairy business. A low estimate places the total production of cheese during the past season of this district at 50,000 boxes, or about 5,100,000 pounds, valued at $530,400, the farmers in that vicinity receiving for their dairy products nearly $1,000,000.

Combinations of boron and chromium and their preparation in the electric furnace is the subject of a paper presented to the Académie des Sciences by M. Binet du Jassonneix. M. Moisson showed that by heating chromium with boron in the electric furnace in a carbon crucible, a very hard crystalline product was obtained, while Tucker and Moody repeated the experiment and prepared an ingot of conchoidal fracture having 82 per cent of chromium, recognizing it as the boride of chromium (CrB). Wedekind and Fetzer claim to have obtained the same compound in a well-crystallized state by the alumino-thermic process. It is strongly resistive to chemical reagents. The reduction of oxide of chromium by boron in the electric furnace in magnesia crucibles gives very different results. Beginning with a carbon crucible, a melted metallic mass is easily obtained, either by the reduction of chromium oxide with boron or by simultaneous reduction of oxide of chromium and boric anhydride by carbon. The ingot presents a crystalline structure and sometimes has geodes lined with crystals, but they are always carbureted. Operating with magnesia crucibles ingots are obtained which are free from carbon and entirely soluble in hydrochloric acid. After two minutes heating in the electric furnace with a current of 400 amperes at 100 volts, we have ingots which, even when the amount of the boron is barely sufficient to reduce the oxide, never contain more than 95 per cent of metal. When the boron increases the fusion is as easily carried out, and after 3 minutes heating an ingot results which contains 15 per cent of boron. The substance is very hard and will scratch glass and quartz. With 7 per cent of boron, it has a good crystalline structure, but it disappears when above this proportion, the grain becoming finer and the fracture conchoidal. The density varies between 6.8 (7 per cent boron) and 6.1 (16 per cent). Using too much boron gives a brittle metallized mass. The ingots which are thus prepared have not an invariable composition, and contain somewhat less boron than the definite boride Cr B, which represents the limit of saturation of chromium by the boron. Most of the acids attack the ingots. Chlorine gas combines with the body with incandescence, when below a red heat. Melted alkalies oxidize them with a bright glow.

M. Balland, of Paris, gives an account of his researches upon the distribution of phosphorus in various food products. He starts with the natural product directly, without reducing it to the state of ash, and made over six hundred analyses. The results of his work are contained in two volumes which he published recently. We will give here a brief summary of some of the leading results which he found for various foods. As regards wheat, the phosphorus, represented by phosphoric anhydride, P_2O_5, varies between 0.65 and 1.11 per cent. These differences, except for Australian wheat, in which the amount is much lower,

are found in the wheat from different parts of the globe. In the oats of commerce he finds about the same amounts. For corn, barley, rye, buckwheat, and millet, the maximum is near 0.80. The variations in green vegetables are more striking than for the cereals. In carrots, cabbage, turnips, beans, onions, he found 0.10 per cent of phosphoric anhydride. In asparagus, chicory, cauliflower, lettuce, and green onions, the maximum is 0.18, while for potatoes and sweet potatoes it is 0.2. Truffles contain as high as 0.50. Among the dried vegetables, peas furnish from 0.61 to 1.00, while beans and lentils give 1.35. In the common fruits such as cherries, strawberries, oranges, pears, apples, grapes, the phosphorus very frequently represents more than 0.10 per cent. For chestnuts it is somewhat higher. Dried figs, dates, bananas give 0.30, while almonds and hazel nuts give 0.90. As regards meats, he finds that beef, veal, mutton, chicken have 0.45 only, which is the average for army canned beef. Fish show a higher figure, about 0.60, and the heads have larger amounts than the bodies. Oysters and mussels show 0.26 to 0.35. It is in the different kinds of cheese that we find the greatest amounts of phosphorus. The maximum, 1.81, is found in Swiss cheese (Gruyère), then come Dutch cheese (Hollande) with 1.61, Port Salut and Cantal 1.28. Roasted coffee grains give a percentage of 0.40, while the used coffee-grounds show only 0.28. In cocoas there is three times as much phosphorus as in coffee, the Madagascar cocoa containing the most, 1.30. Ordinary milk chocolate, as usually prepared, shows 0.62 per 100 parts of liquid. Hen's eggs show 0.26 per cent, with the white representing 0.15 per cent. By treating the yolk with ether about one-half the phosphorus products are taken off. The fatty matters of wheat, extracted by ether, contain 0.32 per cent of phosphoric anhydride, and for oats we have 0.20. The same figure holds good for the fat of meat and cheese extracted in the same way.

TRADE NOTES AND FORMULÆ.

Demagnetization of Tools, Watches, etc.—A process by which tools and watches can be perfectly demagnetized is as follows: An alternating current is carried through a coil of copper wire, shaped cylindrically inside and conically outside. The magnetized object is introduced into the coil, slowly, from the top, and slowly drawn out again. The theory of the process is that when the object is put into the coil, a change in its polarity takes place with each change in the current; when it is removed, the magnetism becomes gradually less, because few lines of magnetic force pass through it. With one turn or winding of the coil the magnetism is not measurable. A magnetic steel tool is inconvenient for use on iron because the filings cling to it. This state of magnetism is often found in turning lathes, where the coils of wire for dynamos are wound. If it once begins, each day finds some other tool in the same condition, until calipers, turning tools, squares, etc., all cling together and attract small screws and filings. To demagnetize the lathe centers, which are the principal cause of this trouble, an apparatus is used consisting of a hollow coil or roll of copper wire connected with an electric lamp socket. An alternating current is passed through the coil and into the magnetic object. The current will correct the condition, if there is enough resistance of the coil. When the articles must be perfectly demagnetized, as in the case of watches, the method first described is preferable; but for tools the second is sufficient.

Niello Work.—The real niello, employed to produce black ornamentation upon silver or other metals, is usually a mixture of silver sulphate, lead sulphate, and copper sulphate, obtained by melting together the ingredients in some one of the following proportions:

	I.	II.	III.	IV.	V.
Silver	8	2	3	1	2
Copper	18	5	5	2	1
Lead	13	3	7	4	—
Sulphur	4	2	6	5	3
Borax	90	30	24	—	—
Sal-ammoniac	—	—	2	—	4

The melted mass is finely pulverized, made into a paste with a solution of borax, and applied in this form to the hollows of the design, which has been made upon the metal with a graving tool. After drying, it is fused in, and finally the surface is polished.

In the case of silver, the niello is pressed into the hollows; with inlaid bronze it is precipitated by means of the electric current. The process is as follows: The design is drawn upon the object to be ornamented, in water colors, usually with white lead. The places not covered by the drawing are covered with varnish, or the design may be made with the varnish, leaving the rest to be etched. The object is placed in dilute nitric acid, where the water color is dissolved, and the etching of the design takes place. When the etching is deep enough, the article is washed in a large quantity of water, and put into a gold or silver bath, where the places which have become uncovered are filled up again with metal. The varnish is now removed, and the surface polished until perfectly smooth and even. The bronzing of the surface is the last operation, and does not affect the tone of the silver or gold. If some parts of the surface, between silver ornaments, are bronzed black with copper sulphate, the design will be black and white on a ground of brownish red cuprous oxide.

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